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Royal College
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Standards for infusion therapy

The RCN IV Therapy Forum

Third edition, January 2010

This publication contains information, advice and guidance to help members of the RCN. It is intended for use within the UK but readers are advised that practices may vary in each country and outside the UK.

The information in this publication has been compiled from professional sources, but its accuracy is not guaranteed. Whilst every effort has been made to ensure the RCN provides accurate and expert information and guidance, it is impossible to predict all the circumstances in which it may be used.

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Published by the Royal College of Nursing, 20 Cavendish Square, London, W1G 0RN

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Acknowledgements

These standards were originally sent to 17 RCN groups and forums, and seven multi-professional organisations for an extensive peer review, as well as the following individuals/groups who were involved in supporting and commenting on the first and second editions of the standards:

Andrew Jackson Nurse Consultant Intravenous Therapy and Care, The Rotherham NHS Foundation Trust

Catherine Howell representing National Blood Service Hospital Liaison Team

Clare Bennett, Becton Dickinson

Dr Eileen Scott Research & Development Co-ordinator, University Hospital of North Tees University Hospital

Infection Prevention Society and IPS IV Forum

Infusion Nurses Society

Julie Lamb Assistant Director Inpatient Services, Barking, Havering & Redbridge Hospitals NHS Trust

Kate Meredith Clinical Product Manager, Becton Dickinson UK Ltd

Medicines and Health care Products Regulatory Agency

National Patient Safety Agency

Professor Tom Elliott Consultant Microbiologist, University Hospital Birmingham

Royal College of Anaesthetists

RCN Children's Society

RCN Critical Care Forum

RCN Palliative Nursing Group

RCN Respiratory Forum

Royal College of Radiologists

Sandra Gray representing RCN Blood Transfusion Forum and Scottish National Blood Transfusion Service Effective Use of Blood Group

Tanya Hawkins Specialist Practitioner of Transfusion (SPOT) (second and third editions)

Thanks also to Martin Keenan and Andrew Jackson (IPS) and Stephen Rowley for reviewing this third edition.

From the authors

Welcome to the third edition of the *Standards for infusion therapy*. We have concentrated on updating sections and references, but we have also changed the order to improve the flow of information.

Foreword

Infusion therapy continues to be associated with a relatively high risk of complications. To decrease this risk it is essential not only to develop standards but also to have practical guidance in implementing them.

The first edition of the *Standards for infusion therapy* developed by the RCN and other multi-professional organisations fulfilled both these requirements, with clearly defined standards supported by practical guidance, and in this third edition these standards have been expanded and updated. The standards are provided as statements that can be readily incorporated into local infusion-related policies and procedures, performance improvement programmes, performance evaluations and educational approaches.

The guidance section provides the health care professional with knowledge to assist in the development of infusion policies and procedures as well as presenting useful guidance on many supplementary areas. Each of the standard statements and guidance have been extensively peer reviewed with supportive literature where available, which acts as an additional resource for health professionals. The supportive literature is also graded to facilitate this process.

The standards deal with all aspects of infusion therapy, ranging from products and documentation, infusion equipment, site selection and care, and prosthetic devices to infusion therapies and related complications. The format of the text is designed to allow ready access to various aspects of infusion therapy. In particular, unlike many guidelines, it also provides clear practical answers to many of the questions which health care workers raise when faced with a list of standards to apply. Without doubt, this document should become a standard in itself and be of value to all health care workers involved in infusion therapy.

Professor TSJ Elliott, BM, BS, BmedSci, PhD, DSc, FRCPath

How to use this document

Each topic covered in this document includes the standard itself and guidance.

- The standard provides criteria for nursing accountability. Statements set out under the standard are to be incorporated into infusion-related policies and procedures, quality assurance and performance improvement programmes, nursing performance evaluations and orientation and educational programmes.
- The guidance section provides specifications for direct implementation of the standard, as well as criteria for evaluating levels of compliance. The guidance section will help health care professionals to develop and implement individual care plans, and provide information for use in the development of infusion policies and procedures.
- Both standards and guidance sections include references to relevant supporting literature and further reading. The reference list will help nurses enhance their knowledge and understanding of a particular infusion practice. In order that the reader may evaluate the strength of the research base, each reference has been graded as follows:
 - I. Randomised controlled trials, including meta-analysis.
 - II. Non-randomised controlled trials and retrospective studies.
 - III. Clinical experience and anecdote. This also includes guidelines based on expert opinion and multiple sources of evidence which may include randomised studies.

(Grading scale adapted from Evans, 2000.)

- Organisational policies and procedures should be developed and implemented based on the standards and the guidance sections.

The document also includes a number of appendices, with diagrams, an index and a glossary.

Definitions

Throughout, the term “health care professional” is used to cover nurses and radiographers. Doctors and radiologists are referred to as medical staff or clinicians.

Abbreviations

The following organisations are referred to by abbreviations throughout this document:

BCSH	British Committee for Standards in Haematology
CDC	Centers for Disease Control and Prevention
DH	Department of Health
HSE	Health and Safety Executive
INS	Infusion Nurses Society
IPS	Infection Prevention Society
MHRA	Medicines and Healthcare products Regulatory Agency
NICE	National Institute for Health and Clinical Excellence
NPSA	National Patient Safety Agency
ONS	Oncology Nursing Society
RCN	Royal College of Nursing
UKPIN	UK Primary Immunodeficiency Network

Introduction

The majority of patients admitted to hospital at the beginning of the 21st Century will become a recipient of a vascular access device at some stage (Petersen, 2002). However, infusion therapy is not confined solely to the hospital setting. Demands for acute hospital beds, changes in treatment regimens, changes in government policy and greater patient participation in treatment decisions are challenging the traditional perception that infusion therapy should be confined to the hospital environment (DH, 2000b; Kayley, 2003; Kayley, 2008). As a consequence of the advances in technology, a range of vascular access devices are emerging that can meet the clinical requirements of individual patients at the same time as suiting their lifestyles, making community-based infusion therapy an increasingly viable option (Gabriel, 2000; Gabriel *et al.*, 2005; Kayley, 2008). However, the diversity of vascular access devices does have implications for practice; nurses, and clinicians must ensure that each patient receives the most appropriate infusion therapy.

Scope of practice

Infusion therapy is now an integral part of professional practice for the majority of nurses. Nursing involvement ranges from caring for an individual with a peripheral cannula *in situ*, to nursing a patient with multiple parenteral and haemodynamic therapies in the critical care environment. Whatever the route, peripheral or central, infusion therapy is not without risk (Gabriel *et al.*, 2005; Scales, 2008). Infusion nursing is not limited just to the care of the patient and the device. Increasingly nurses are responsible for the insertion and removal of the device and are also often responsible for procurement of the consumables

associated with infusion therapy. Consequently, the range and depth of professional involvement related to infusion therapy will depend on the extent of an individual nurse's commitment.

In 1992 the then regulatory body for nurses in the UK, the UK Central Council for Nursing, Midwifery and Health Visiting (UKCC), published *The scope of professional practice* (UKCC, 1992). This document was instrumental in helping nurses to develop their individual practice for the benefit of patients, the proviso being that the nurse is knowledgeable and skilled for the role he/she is undertaking. In 2002, the Nursing and Midwifery Council (NMC) replaced the UKCC. The NMC's first professional document was *The code of professional conduct* (NMC, 2002), which not only encouraged nurses to expand their practice, provided they had the necessary knowledge and skills and accepted responsibility for their actions, but also recognised the importance of involving patients/clients in decisions affecting their care. The updated 2008 version of *The Code* (NMC, 2008b) emphasises the need to deliver care based on the best available evidence, which strongly supports the need for robust standards of practice for infusion therapy. Knowledge and skills must be kept up to date and nurses must take part in appropriate learning and practice activities to maintain and develop their competence (NMC, 2008b).

Involving patients/clients

The priorities for patients requiring infusion therapy in the emergency or acute care setting are largely dependent upon their clinical needs. Generally, these patients will be recipients of a vascular access device for a comparatively short period of time, and may be

too unwell to contribute to discussions on device selection. However, when the administration of intravenous medications or fluids is considered in the longer term, many patients will be well enough to participate in decisions around device selection and site selection. Despite the move towards increased patient involvement, there is little published evidence to support user involvement in the selection of vascular access devices, despite the fact that patients may be expected to “live” with their vascular access device and treatment in the home environment (DH, 2000b; Gabriel, 2000; Nugent *et al.*, 2002; NPSA, 2003; Kayley, 2008).

When selecting vascular access devices and treatment regimens it is important to consider the patient’s lifestyle as well as their clinical situation. Younger patients will have differing considerations to older people. Some individuals will have access to supportive carers, while others will be socially isolated. Some individuals will have the mental capacity and manual dexterity to be involved in their infusion therapy, while others may not. Infusion therapy may only be one element of a patient’s health care needs. All these factors need to be taken into consideration when assessing each patient for infusion therapy.

Patient assessment

Patient assessment is not just about identifying the most suitable vein in which to site an IV cannula. It should start by identifying what medications the patient will require for their clinical needs and by what route(s) they can be administered. If the intravenous route is required, account should be taken of how long the treatment is intended to last, whether the drugs or infusates are vesicant, how frequently and what volumes are to be infused, and whether the treatment will be administered in hospital or at home. The osmolarity and pH of the agents should also be considered. This should then be matched against the various vascular access devices – peripheral cannulae, midline catheters, central venous access devices – to decide which is the most suitable for the individual patient. Where possible, and certainly for a prolonged course of treatment, the patient should be consulted about the choice of vascular access device and where it is sited. This consultation should include all the relevant

information in order for the patient to reach an informed decision (Gabriel *et al.*, 2005).

Evidence-based care

The NMC’s Code (2008) clearly states that individual nurses have a responsibility to deliver evidence-based care. Patients have the right to receive a uniformly high standard of care, regardless of who they are and where they are treated (DH, 2000b). The production, implementation, audit and regular updating of clinical standards to reflect the latest research findings will ensure that all patients can benefit from safe and appropriate care.

Infection Control

The importance of using effective infection control measures is integral to all aspects of infusion therapy. Aseptic technique is a common term used to define necessary infection control measures to prevent pathogenic micro-organisms on hands, surfaces or equipment from being introduced to susceptible sites such as IV devices during clinical practice. A best practice example is aseptic non-touch technique (ANTT) comprising a number of fundamental components including reducing environmental risks, hand cleansing, non-touch technique protection for ‘key parts’, correct cleaning of ‘key parts’, use of gloves and sterile fields (Rowley & Laird, 2006).

Research

Advances in clinical care depend on research and dissemination of its findings. When a new therapy, method of delivery or indeed a new piece of equipment require clinical evaluation, patients’ views should be sought. Clinical governance arrangements for research require all such studies to be reconciled with the welfare of the research subjects in light of the broader ethical implications (Royal College of Physicians, 1996; DH, 2001d; North and Mid Hants LREC, 2002). Essentially, this means that no patient should be disadvantaged by receiving a known inferior treatment to answer medical curiosity. Where there is no intended clinical benefit for the individual participating in the study, this information should be

clearly communicated to them. It is then up to the patient whether they wish to participate or not. If they decline, their current and future care should not be adversely affected by such a decision.

Research should be employed to expand the base of nursing knowledge in infusion therapy, to validate and improve practice, to advance professional accountability, and to enhance decision-making (INS, 2006). Where appropriate, nurses should actively participate in infusion therapy research activities that are relevant to their job responsibilities, education, experience and practice setting (INS, 2006).

Consent

“It is a general legal and ethical principle that valid consent must be obtained before starting treatment or physical investigation or providing personal care” (DH, 2001d). All patients have a right to receive accurate information about their condition and intended treatment. It is the responsibility of the individual practitioner proposing to carry out the treatment to ensure that the patient understands what is proposed (NMC, 2008b). Consent can be given orally, in writing or by co-operation (NMC, 2008b). Children under the age of 16 can give consent providing that they are legally competent. However, it is considered good practice to involve the individual with parental responsibility in all discussions where consent to treatment is required for a child (DH, 2001a). Parents can consent to treatment on behalf of children under 16 but again it is considered good practice to include the child in discussions (DH, 2002c).

Conclusion

Infusion therapy has increased in complexity over the years. These guidelines are intended to help individual practitioners ensure that patients receive the most appropriate care for their individual circumstances.

1

Education and training

1.1 Staff education

Standard

The nurse inserting devices and/or providing infusion therapy should be competent in all clinical aspects of infusion therapy and have validated competency in clinical judgement and practice, and practice in accordance with the NMC's *Code*: that is, they will maintain their knowledge and skills (Collins *et al.*, 2006; NMC, 2007; Hyde, 2008; NMC, 2008).

Guidance

Registered nurses undertaking the insertion of vascular access devices will have undergone theoretical and practical training in the following:

- anatomy and physiology of the circulatory system, in particular, the anatomy of the location in which the device is placed including veins, arteries and nerves and the underlying tissue structures
- assessment of patients' vascular access needs, nature and duration of therapy and quality of life
- improving venous access, for example the use of pharmacological and non-pharmacological methods
- selection of veins and problems associated with venous access due to thrombosed, inflamed or fragile veins, the effects of ageing on veins, disease process, previous treatment, lymphoedema or presence of infection
- selection of device and other equipment
- infection control issues (hand-washing, skin preparation)
- pharmacological issues (use of local anaesthetics, management of anxious patients, management of haematoma, phlebitis, etc.)

- patient's perspective on living with a vascular access device
- risk management in order to reduce the risk of blood spills and needlestick injury
- professional and legal aspects (consent, professional guidance, knowledge and skill maintenance, and documentation)
- performing the procedure
- prevention and management of complications during insertion (nerve injury, haematoma, etc.)
- monitoring and care of the site (flushing, dressing, removal, etc.)
- product evaluation
- patient information and education
- documentation
- specific training for insertion of vascular access devices in certain groups, for example neonates, children and oncology patients.

Nurses undertaking the administration of infusion therapy and care and management of vascular access devices will have undergone theoretical and practical training in the following aspects (Lonsway, 2001; Kayley and Finlay, 2003; MDA, 2003; NICE, 2003; NPSA 2003; DH, 2004a; RCN, 2005b; Pratt *et al.*, 2007; NPSA, 2007b; Hyde; NMC, 2008a; Hyde, 2008; NMC, 2008b; MHRA, 2008).

- legal, professional and ethical issues
- anatomy and physiology
- fluid balance and blood administration
- mathematical calculations related to medications
- pharmacology and pharmaceuticals related to reconstitution and administration
- local and systemic complications
- infection control issues
- use of equipment, including infusion equipment
- drug administration
- risk management/health and safety
- care and management of vascular access devices

- infusion therapy in specialist areas covered separately (paediatrics, oncology, parenteral nutrition, transfusion therapy) (Corrigan, 2009a).

All staff have a professional obligation to maintain their knowledge and skills (NMC, 2008b). It is also the responsibility of the organisation to support and provide staff with training and education.

1.2 Patient and caregiver education

Standard

The patient, caregiver or legal representative must receive instruction and education related to the vascular access device, prescribed infusion therapy, infection control and plan of care (NICE, 2003).

The patient, caregiver or legal representative must be informed of potential complications associated with treatment or therapy (Dougherty, 2006).

The nurse should document the information given and the patient's, caregiver's, or legally authorised representative's response in the patient's medical and nursing notes (Weinstein, 2007).

Education and training of patients or caregivers should be in accordance with *The Code* (NMC, 2008b) and *Standards for medicines management* (NMC, 2008a).

The practitioner responsible for educating and training patients and caregivers to administer intravenous therapy should ensure that reasonable foreseeable harm does not befall a person as a consequence of his/her instructions and delegation (of care) (NMC, 2008b).

Guidance

- The patient, caregiver or legal guardian should be given a demonstration and a set of verbal and written instructions that are tailored to his or her cognitive, psychomotor and behavioural abilities (Hamilton, 2000; RCN, 2001; Camp Sorrell, 2004; INS, 2006).
- The patient, caregiver or legal guardian should demonstrate understanding and the ability to perform procedures and care (RCN, 2001; NICE, 2003; UKPIN, 2005).
- The intravenous therapy to be administered by the patient/caregiver should be assessed as appropriate for administration in the home environment (UKPIN, 2005; Kayley, 2008).
- An assessment as to the appropriateness of the home setting for the preparation, administration and storage of intravenous therapy and equipment should be undertaken (Kayley, 2008).
- Education, training and written information should be provided that includes the storage of the drug and equipment, aseptic technique and hand-washing, preparation and administration of the drug and infusion delivery equipment, care and maintenance of the vascular access device, side-effects of therapy, prevention of spillage of hazardous waste, and management and recognition of allergic/anaphylactic reactions (Dobson *et al.*, 2004; UKPIN, 2005; RCN, 2001; NICE, 2003; Kayley, 2008).
- The patient/caregiver should be assessed for ability and willingness to undertake administration of intravenous therapy (RCN, 2001; UKPIN, 2005; Kayley, 2008).
- The patient, caregiver or legal guardian should be informed in clear and appropriate terminology about all aspects of the therapy, including the physical and psychological effects, side-effects, risks and benefits (NICE, 2003; UKPIN, 2005; INS, 2006; Kayley, 2008).

2

Infection control and safety compliance

2.1 Infection control

Standard

All infusion related procedures require the use of aseptic technique, observation of standard precautions and product sterility. Thorough hand-washing techniques must be employed before and after clinical procedures (DH, 2005b; Rowley & Laird 2006; Pratt *et al.*, 2007).

Sterile gloves and maximal sterile barrier precautions must be used when performing infusion procedures such as insertion of central venous access devices (Pratt *et al.*, 2007).

All disposable blood-contaminated and/or sharp items – including, but not limited to, needles or stylets and surgical blades – must be disposed of in non-permeable, puncture-resistant, tamper-proof containers which comply with UN 3921 and BS7320 standards, and should be located at a suitable and safe level in places which are not accessible to the public (HSE, 2002; IPS, 2003).

Non-disposable equipment such as surgical instruments requiring re-sterilisation should be handled according to manufacturers' guidelines for sterilisation of items posing a hazard. However, disposable equipment should be used wherever possible.

All products requiring disposal must be managed in line with HTM07-01 and local policy.

Morbidity and mortality rates associated with catheter-related infections should be reviewed, evaluated and reported on a regular monitored, reviewed basis.

A quality assurance and performance improvement programme incorporating infection control practices should be implemented to minimise potential for

development of health care associated infection and to provide corrective action, when necessary (DH, 2005b).

Guidance

- The elements of, and protocol for, aseptic technique should be established in organisational policies and procedures (NICE, 2003; RCN, 2005a; Hart, 2008a).
- A protocol for ascertaining product integrity and sterility should be established in organisational policies and procedures.
- Practitioners performing procedures that result in the generation of droplets or splashing of blood and/or body fluids should employ appropriate personal protective equipment including well-fitting gloves, mask, gown, protective eyewear and drapes (IPS, 2003; Pratt *et al.*, 2007).
- Regulation sharps containers should be placed at multiple convenient and safe locations, should be easily accessible and, when filled to the fill line, should be sealed shut and labelled with the patient's name/ward/clinic and dates. They should then be disposed of by designated personnel (Hanrahan and Reutter, 1997; Health Service Advisory Committee, 1999).
- Ideally, all needles should have a safety device, with engineered sharps injury protection, to minimise the potentially serious consequences of exposure to bloodborne pathogens and the potential for permanent and disabling injury (UK Health Departments, 1998). Risk assessments should be undertaken, and the use of these devices considered in line with local policies.
- Performance improvement measures, including site rotation and administration set changes, should be implemented in accordance with the standards incorporated in this document.
- Infection statistics should be documented and retained by each organisation (DH, 2005b).
- A robust system for learning from incidents, such as infection, should be in place.
- The Centers for Disease Control and Prevention (CDC, 2002) standard for infection rate calculation is:

$$\frac{\text{Number of IV device related infections}}{\text{Total number of catheter days}} \times 1,000 = \frac{\text{Number of IV device-related infections}}{1,000 \text{ catheter days.}}$$

2.2 Hand-washing

Standard

Hand-washing should be performed before and immediately after each episode of patient contact. This include clinical procedures, and before putting on and after removing gloves.

Guidance

- Hand-washing should be a routine practice established in organisational policies and procedures (RCN, 2005a; Hart, 2008b; Sax *et al.*, 2007).
- Hands that are visibly soiled or potentially grossly contaminated with dirt or organic material should be washed with liquid soap and water (NICE, 2003; DH, 2007h; Pratt *et al.*, 2007).
- Care should be taken to prevent contamination of liquid soap or antiseptic dispensers. These containers should be discarded and replaced according to organisational policies and procedures (DH, 2005b).
- Paper hand towels should be used to dry the hands, as hot air dryers are not recommended in clinical settings (DH, 2007h; Pratt *et al.*, 2007).
- Alcohol handrub should be used when hands are clean or when running water is compromised or unavailable. The alcoholic handrub should be rubbed over all areas of the hands and wrists vigorously until the solution has evaporated and the hands are dry (DH, 2005b).
- All wrist and hand jewellery should be removed at the beginning of each clinical shift, and cuts and abrasions covered with a waterproof dressing. The fingernails should be kept short and clean; the wearing of nail varnish, false nails and nail art are inappropriate as they are a potential reservoir for micro-organisms (Jeanes & Green 2001; Pratt *et al.*, 2007).

- Staff should not wear any clothing below the elbow.

2.3 Personal protective equipment (PPE)

2.3.1 Gloves

Standard

Gloves should be used when performing infusion related procedures.

Guidance

- The use of gloves is not a substitute for hand-hygiene. Hand-hygiene should be performed before and immediately after procedures, and before putting on and after removing gloves (Pratt *et al.*, 2007).
- Gloves do not provide protection against needlestick injury, but should be worn to protect hands from contamination from organic matter, micro-organisms and toxic substances, and to reduce the risk of cross-contamination to both patient and staff (Hart, 2008b).
- Gloves must conform to European Community standards (CE) and must be of a suitable quality (Pratt *et al.*, 2007).
- Gloves must be available in all clinical areas (Pratt *et al.*, 2007).
- Powdered and polythene gloves should not be used for infusion procedures (Pratt *et al.*, 2007).
- Gloves should be well fitting; gloves which are too small may be punctured by the wearer's fingernails, while gloves which are too large may impede manual dexterity (Pratt *et al.*, 2007).
- Following removal, gloves must be discarded in an appropriate clinical waste bag (Pratt *et al.*, 2007).
- For practitioners and patients who are sensitive to natural rubber latex, alternative gloves must be made available and their use should be supported in the local policies and procedures (Pratt *et al.*, 2007).

- The choice of sterile or non sterile gloves should be made based on an assessment of the technical difficulty of the procedure and not the diagnosis of the patient. For example if using ANTT then non-sterile gloves can be worn for peripheral and central venous access device management, as long as there is no necessity to touch the key parts of the procedure directly (Rowley & Laird, 2006).

2.3.2 Plastic aprons

Standard

Disposable plastic aprons should be worn during the performance of infusion procedures.

They are single use items and must be disposed of after use and before the next task is initiated.

Guidance

- Where there is a risk of contamination by blood and bodily fluids, a disposable plastic apron should be worn to prevent contamination of clothing (Pratt *et al.*, 2007).
- The apron should be worn for a single procedure and then discarded and disposed of as clinical waste (Pratt *et al.*, 2007).

2.3.3 Face masks, caps and eye protection

Standard

The wearing of a face mask and cap is not essential during the performance of infusion procedures.

Protective clothing should be worn when the practitioner is at risk from splashes of substances or body fluids (Pratt *et al.*, 2007).

Guidance

- There is no evidence to suggest that wearing a face mask and cap during central venous catheter insertion reduces the incidence of infection to the patient (Pratt *et al.*, 2007).
- To prevent possible infection of staff, face masks, caps and eye protection should be worn when there is a risk that the procedure could cause hazardous substances or body fluids to splash into the face, eyes or mouth (COSHH, 2002; Pratt *et al.*, 2007).

- When delivering infusion therapy to a patient with a respiratory infection with airborne transmission a correctly fitted particulate filter mask be worn (Pratt *et al.*, 2007).

2.3.4 Gowns

Standard

The wearing of a sterile gown should be part of the maximal barrier precautions during central venous access device insertion (Pratt *et al.*, 2007).

Guidance

- The risk of infection during insertion of central vascular access devices is significantly higher than for short peripheral cannulae and wearing a sterile gown will reduce this risk (Pratt *et al.*, 2007).

2.4 Reconstitution

Standard

Chemical, physical, and therapeutic properties and compatibilities must be ascertained prior to reconstituting medications using aseptic technique (NPSA, 2007b).

A laminar flow hood or isolator must be used for reconstitution of medicines which are hazardous to health, for example cytotoxic drugs, in accordance with national guidance (COSHH, 2002; HSE, 2003). Ideally, all drugs should be available in a ready-to-use form that is either pre-prepared by pharmacy or purchased pre-prepared from a pharmaceutical company (NPSA, 2007b).

Guidance

- Protocol for reconstitution should be established by and conducted under the direction of the pharmacy (NPSA, 2007b).
- The list of medications that the nurse may not reconstitute should be set out in an organisational policy (NPSA, 2007b).

- Where possible, injections/infusions that are in a ready-to-use form should be used (NPSA, 2007b). If this is not available a risk assessment should be completed to determine the most appropriate location for preparation and any action required to minimise the hazards (NPSA, 2007b).
- The nurse should have a thorough knowledge of the principles of reconstituting, including, but not limited to, aseptic technique, compatibility (physical, chemical and therapeutic), stability, storage, labelling, interactions, dosage and calculations (see Appendix 3) and appropriate equipment (Taxis and Barber, 2003; NMC, 2008b; Hopwood, 2008).
- Reconstituting procedures and safeguards should be congruent with standards set by the COSHH (2002), NMC (2007) and NPSA (2007b).
- Prepared medicines should not be stored even for a short period without being labelled, and labels should include the name of the medicine, strength, route, diluent and final volume, the patient's name, expiry date and name of practitioner preparing the medicine (Cousins *et al.*, 2005; NPSA, 2007b).
- Aseptic technique should be used throughout reconstitution. This includes adequate cleaning of additive ports of infusion bags and the tops of medicine vials and ampoules (NPSA, 2007b).
- Where used, the nurse should be trained and know the general operating procedures for the use of a laminar flow hood/isolator (INS, 2006; Weinstein, 2007; Hyde, 2008).
- Maintenance, quality assurance and performance improvement measures should be implemented based on appropriate national regulations, manufacturers' guidelines and recommendations (Weinstein, 2007).

2.5 Compatibility

Standard

Chemical, physical and therapeutic compatibilities must be ascertained prior to the reconstitution and administration of prescribed infusion medications.

Compatibility between medications and delivery systems must be ascertained prior to the administration of prescribed infusion medications (NPSA, 2007b).

Guidance

- Manufacturers' guidelines should be followed for reconstituting and administration of a specific medication (Weinstein, 2007).
- A registered pharmacist should be consulted on issues of compatibility (Trissel, 2006; NPSA, 2007b).
- Adequate flushing should be performed between the administration of each drug to prevent incompatibilities from occurring (NPSA, 2007b; Finlay, 2008; Hopwood, 2008).
- Use of multi-lumen catheters can help to reduce the risk of drug incompatibilities (Whittington, 2008).

2.6 Expiry dates

Standard

Medications must not be administered, and products and equipment must not be used beyond their expiry dates (INS, 2006; NSPA, 2007b).

Guidance

- Manufacturers' guidelines for proper storage of medication should be followed to ensure the validity of the expiry date (Whittington, 2008).
- Expiry dates should be verified prior to initiation or administration of therapy (NMC, 2008a).
- Expiry dates should be verified by the health care professional by checking supplementary information received from the manufacturer, or by checking labels attached to the medication, product or equipment.
- The maximum expiry date for any injection/infusion prepared in a clinical area is 24 hours or less in accordance with the manufacturer's specification of product characteristics (NPSA, 2007b).

2.7 Safe use and disposal of sharps and hazardous material

Standard

All devices should have engineered sharps injury protection mechanisms: these mechanisms should be activated immediately after use and prior to disposal (INS, 2006; Pratt *et al.*, 2007).

All used disposable sharp items – including, but not limited to, needles or stylets and surgical blades – should be disposed of in a non-permeable, puncture-resistant, tamper-proof container complying with UN 3921 and BS7320 standards located in a near-patient location or a patient's home (INS, 2006; Pratt *et al.*, 2007).

Sharps must not be resheathed, broken or bent (IPS, 2003; NICE, 2003; RCN, 2005a; NHS Employers, 2007; Pratt *et al.*, 2007).

Needles and syringes must not be taken apart by hand prior to disposal (Hart, 2008b).

All hazardous materials (for example cytotoxic drugs) and wastes should be discarded in the appropriate containers according to national guidelines and organisational policies and procedures (COSHH, 2002; RCN, 2007b).

Guidance

- Protocols for training and safe handling of hazardous materials and hazardous waste as well as prevention and reporting of sharps injuries should be set out in organisational policies and procedures (Pratt *et al.*; HPA, 2008; RCN, 2009).
- The manufacturer's guidelines, standards of practice and national regulations should be adhered to when developing organisational policies and procedures pertaining to the safe handling of hazardous materials, hazardous and paper waste (RCN, 2007b).
- Because of the potentially serious consequences of exposure to bloodborne pathogens and the potential for permanent and disabling injury, ideally all needles should have a safety device with engineered sharps injury protection (IPS, 2003; NHS Employers, 2007).

- Exposure to potentially infectious materials or injury from sharps should be identified, reported, tracked and analysed for trends. Corrective action should be taken (IPS, 2003; NHS Employers, 2007; RCN, 2009).
- All sharps must be accounted for before, during and immediately upon completion of a procedure (IPS, 2003).

2.8 Cleaning and sterilising reusable equipment

Standard

All medical equipment, dressings and solutions used during invasive procedures must be sterile.

All medical equipment such as drip stands, mechanical and electronic infusion devices etc. must be cleaned routinely and following patient use (INS, 2006).

Cleaning should be followed by disinfection, if necessary, in line with local policy.

Sterilisation and disinfection solutions must be in accordance with manufacturers' guidelines.

Disinfection solutions must be bactericidal, virucidal, fungicidal, sporicidal and tuberculocidal.

Single-use devices are meant for single use only and must not re-used (MDA, 2000).

Guidance

- Protocols for disinfection of medical equipment should be set out in organisational policies and procedures (Fullbrook, 2007).
- To prevent cross-infection, cleaning of medical equipment should be performed prior to patient use and at established intervals during long-term single-patient use (MDA, 2000).
- Cleaning of medical equipment should include drip stands, electronic infusion devices, splints and other non-disposable infusion-related equipment used in providing patient care (MHRA, 2006).
- The disinfection solution should not cause damage that could alter the integrity or performance of the equipment.

3

Products and documentation

3.1 Product requirements

Standard

All medical devices must have a CE marking. (The CE mark certifies that a product has met EU consumer safety, health or environmental requirements. CE stands for ‘Conformité Européene’ which means ‘European Conformity’).

Guidance

- Any product not meeting the CE marking requirements should be withdrawn from use and reported to the Medicines and Health care products Regulatory Agency (EU Directive 1993; MHRA, 2007).

3.2 Product defect reporting

Standard

All product defects must be reported in writing to the appropriate department within the organisation, national regulatory agencies such as the MHRA or the NPSA, and the manufacturer (MHRA, 2008a).

Guidance

- All organisations should have a policy for reporting product complaints.
- Product complaints should include any suspected damage, incorrect labelling, packaging damage or tampering.
- Any contaminated product must be dealt with according to the organisation’s policy and should be decontaminated.
- Product reports should include details of the complaint, the effect of the defect on the procedure, if any, and the lot number of the product.

- Product complaints should be reported to the MHRA, the manufacturer and the appropriate department within the organisation (MHRA, 2008a).
- All adverse incidents must be reported as soon as possible to the MHRA via the most appropriate method and should contain as much relevant detail as available.

3.3 Labelling

Standard

Colour labels/packaging/products should not be relied upon for product or drug identification.

Clear, accurate labelling should be used for product and drug identification.

Guidance

- European Law, Directive 92/27/EEC specifies the requirements for the labelling of medicines (BMA and RPS, 2008). Labelling for drugs should include the brand name and the generic name with prominence given to the generic name. Other information that should be included when labelling medicines includes the name of the drug, its strength (amount per unit volume) and total amount in volume, route of administration, dosage and warnings (Committee on Safety of Medicines, 2001; MHRA, 2003; DH, 2004a). European law requires the use of recommended International Non-Proprietary Names (rINNs) in the packaging and labelling of medicinal substances (DH, 2004c; MHRA, 2005b; BMA and RPS, 2008).
- Labelling for catheter products should include: size, gauge, length and material (INS, 2006).
- All injections and infusions (including flushes) must be labelled immediately after preparation by the person who prepared them. The only exception to this is syringes intended for immediate push (bolus) administration by the person who prepared them. Only one unlabelled medicine must be handled at one time. “Flag labelling” should be used to ensure that the volume graduations on small syringes are not obscured (NPSA, 2007f).

- Labels used on injectable medicines prepared in clinical areas should contain the following information: name of the medicine; strength; route of administration; diluent and final volume; patient's name; expiry date and time; and name of the practitioner preparing the medicine (NPSA, 2007f).
- Infusion bags and syringes for epidural therapy should be clearly labelled with "For Epidural Use Only" in a large font. Clearly labelled epidural administration sets and catheters distinct from those used for intravenous and other routes should be used (NPSA, 2007d).

3.4 Patient safety incidents

Standard

A patient safety incident report should be used to document incidents that could have or did lead to harm (NPSA, 2004).

Health care providers must have in place a holistic and integrated system covering management, reporting, analysis and learning from all patient safety incidents involving patients, staff and others, and other types of incidents not directly involving people (NPSA, 2004).

Guidance

- The patient safety incident report must be managed and reported to a designated person or persons in accordance with local and national organisational policies and procedures.
- Patient safety incidents should be reported locally using a centralised risk management system and nationally via the National Reporting and Learning System (NPSA, 2004; NPSA, 2007g).
- All reported incidents must be graded, investigated and analysed in accordance with local and national organisational policies and procedures.
- Serious untoward incidents should be reported to the appropriate strategic health authority and the Department of Health (NPSA, 2004).
- Any adverse incident involving a medical device must be reported to the MHRA using the adverse incident reporting system (MHRA, 2008a).

- Improvement strategies that aim to reduce risk to future patients should be implemented and monitored by the health care provider (DH, 2001a).
- Adverse drug reactions and defects with medicine products should be reported directly to the MHRA (NPSA, 2004).

3.5 Research, audit and benchmarking

Standard

Registrants have a responsibility to deliver safe and effective care based on current evidence, best practice, and where applicable, validated research (NMC, 2006a; NMC, 2008b).

Research and audit should be used to expand the base of nursing knowledge in infusion therapy, to validate and improve practice, to advance professional accountability, and to enhance evidence-based decision-making (INS, 2006; RCN, 2007a).

Clinical practice benchmarking should be used as an improvement tool to share and compare best practice and ultimately develop practice through action planning and implementation (RCN, 2007a).

Guidance

- The research, audit and benchmarking programme should be in line with national guidelines, available research and professional standards of practice (DH, 1998; Stark *et al.*, 2002; RCN, 2007a).
- The audit and performance improvement strategy should provide accountability criteria and expected treatment outcomes (Ellis, 2000).
- Audit should be an ongoing process in order to monitor, maintain and improve clinical practice in infusion therapy. Identified deficiencies should be documented and evaluated, and form the basis of an action plan for performance improvement (DH, 2005a; Pratt *et al.*, 2007). See Appendix 7 for examples of audit tools.

- The health care professional should be competent in research utilisation with the ability to interpret and critically evaluate the outcomes of research studies, implement research-based innovations in clinical practice, or share knowledge through research dissemination (INS, 2006).
- Research should be conducted in accordance with the *Research governance framework for health and social care* (DH, 2005a) and must be approved by a Research Ethics Committee (REC) (RCN, 2007a).
- Organisations should audit complications associated with peripheral cannulation (DH, 2007d) and central venous catheterisation, and use the data to develop preventive measures (Bishop *et al.*, 2007; DH, 2007d).
- This should include infective episodes and other adverse events.
- Local audit should include patient identification data, diagnosis, date of catheter insertion, number of previous catheters, operator and department where the catheter was inserted, complications associated with the catheter, date of and reason for removal. Each unit should monitor their infection rates per 1,000 catheter days to observe any changes or trends in infection rates (Bishop *et al.*, 2007).
- Information obtained as a result of audits must be disseminated promptly and evaluated by practitioners involved in the provision of IV related care in order to develop a culture of learning and quality improvement.
- The *Epic2 national evidence-based guidelines for preventing health care-associated infections in NHS hospitals in England* should be used as a baseline for clinical audit and to facilitate ongoing quality improvements (Pratt *et al.*, 2007).

3.6 Documentation

Standard

Documentation in the patient's nursing and/or medical record must contain complete information regarding infusion therapy and vascular access, and adverse drug reactions (IPS, 2000; INS, 2006; NMC, 2008a; NPSA, 2007f).

Documentation must comply with the guidelines for records and record-keeping (NMC, 2005) and *The Code* (NMC, 2008b).

General guidance

- The protocol for documentation should be set out in organisational policies, procedures and practice guidelines.
- All aspects of intravenous therapy and vascular access should be documented according to local policy, procedures, national and professional guidance (Finlay, 2008). Documentation should include:

Documentation of the insertion of the VAD (vascular access device)

- a) Evidence of informed consent (Camp Sorrell, 2004; Weinstein, 2007; NMC, 2008b).
- b) The date and time of insertion of the vascular access device (VAD) (DH, 2003d; Camp Sorrell, 2004; DH, 2007d; DH, 2007c; Weinstein, 2007).
- c) The reason for insertion of the VAD (Pratt *et al.*, 2007).
- d) Details of site preparation (Camp Sorrell, 2004).
- e) The number and location of insertion attempts (Weinstein, 2007), details of the insertion technique utilised, e.g. use of ultrasound or micro-introducer (Camp Sorrell, 2004; Dougherty, 2006; Weinstein, 2007).
- f) The insertion site including actual vein(s) used (Dougherty, 2006; Pratt *et al.*, 2007; Weinstein, 2007).
- g) The name of the person placing the device.
- h) Problems encountered during insertion (Camp Sorrell, 2004; Dougherty, 2006).
- i) The appearance of the catheter site after insertion, e.g. any bruising or bleeding, type of dressing and securement device utilised (Dougherty, 2006; Weinstein, 2007).
- j) Which sedative or local anaesthetic is used (Camp Sorrell, 2004; Dougherty, 2006; Weinstein, 2007).

- k) Flush solution(s) used, including the amount of solution used (Dougherty, 2006; Weinstein, 2007).
- l) The functionality of the catheter immediately post-insertion, e.g. presence of blood return and ability to flush device easily (Camp Sorrell, 2004; Weinstein, 2007).
- m) Actual length of catheter inserted (Dougherty, 2006; Weinstein, 2007).
- n) Method of verifying catheter tip location (Weinstein, 2007). Radiographic confirmation of the location of catheter tip if required (Camp Sorrell, 2004; INS, 2006).
- o) The patient's tolerance of the insertion procedure (Dougherty, 2006; Weinstein, 2007).
- f) Specific safety or infection control precautions taken (INS, 2006).
- g) Patient or caregiver participation in and understanding of therapy and procedures (INS, 2006).
- h) Patient/caregiver teaching and any written information given to the patient/caregiver (Camp Sorrell, 2004; Dougherty, 2006; Weinstein, 2007). Activity restrictions (Camp Sorrell, 2004).
- i) Manufacturer's registration card, hospital information card or patient-held record with all information about the VAD and maintenance care required and contact numbers in case of problems/queries (Weinstein, 2007).
- j) Communication among health care professionals responsible for patient care and monitoring (INS, 2006). Whether the community nurses have been informed of VAD insertion (Camp Sorrell, 2004; Dougherty, 2006).
- k) Catheter replacements (Pratt *et al.*, 2007).

Documentation of the VAD

- a) Type of device, size/gauge/length of VAD, number of lumens (Camp Sorrell, 2004; Dougherty, 2006; Pratt *et al.*, 2007; Weinstein, 2007).
- b) The manufacturer, lot/batch and number, and expiry date (MHRA, 2005c; Dougherty, 2006).
- c) External catheter length at the insertion site (Dougherty, 2006; Weinstein, 2007).

Documentation of ongoing care and maintenance

- a) Details of catheter care (Pratt *et al.*, 2007).
- b) Site care and condition/appearance using standardised local assessment scales for phlebitis and/or infiltration/extravasation (Lamb and Dougherty, 2008).
- c) Assessment of insertion/exit site for redness, oedema, rashes, discoloration, any drainage/discharge and intactness of VAD (Camp Sorrell, 2004).
- d) Flush solution(s) used, i.e. type, volume, frequency, difficulties encountered. Cap changes (Camp Sorrell, 2004).
- e) Methods to evaluate proper functioning of the VAD prior to use (Camp Sorrell, 2004).

Documentation of infusion therapy

- a) Clear, accurate and detailed record of intravenous medicines administered, as soon as possible after the event (NMC, 2008a; NPSA, 2007f).
- b) Type of therapy administered: drug, dose, rate, route, time and method of administration (INS, 2006).
- c) Pertinent diagnosis, assessment and monitoring of vital signs (INS, 2006).
- d) Patient's tolerance/response to therapy, symptoms and/or appropriate laboratory tests taken and results documented (INS, 2006).
- e) Record any adverse drug reactions in the patient record (NMC, 2008a).
- f) Any adverse events, complications of therapy or VAD use should be documented (Weinstein, 2007).

- g) Record the results of any monitoring, e.g. site assessment in the patient record, prescription chart or monitoring chart according to local policy (NPSA, 2007k).
- h) Record the administration in the patient notes, prescription chart and/or other patient-held record, as appropriate, according to local guidelines/policies (NPSA, 2007j).

Documentation of complications of VAD use

- a) Document any complications and side-effects of infusion therapy (INS, 2006).
- b) Date, time and situation when complication noted. Complication(s) noted when using the VAD. Strategies used to manage complications and evaluation of effectiveness (Camp Sorrell, 2004).
- c) Documentation of extravasation incidents (Dougherty, 2006).

Documentation of removal of VAD/end of therapy

- a) Date and time of removal, procedures used to remove VAD, any complications during removal of VAD, the catheter length and integrity of the VAD on removal (Camp Sorrell, 2004), appearance of the site, and type of dressing applied after removal (INS, 2006).
- b) Reason for removal of the VAD (INS, 2006).
- c) Patient response to removal of the VAD (Camp Sorrell, 2004).
- d) Discontinuation of therapy (DH, 2003).

4

Infusion equipment

4.1 Add-on devices

Standard

Add-on devices include three-way taps/stopcocks, ramping 'traffic light' systems, extension sets, blind hub caps, injectable caps/connectors, needleless systems and filters. All add-on devices should be of Luer-Lok™ design. Aseptic technique must be used and standard precautions must be observed for all add-on device changes (INS, 2006).

Guidance

- Protocols for the use of add-on devices should be established in organisational policies and procedures.
- Protocols for the use and frequency of change of add-on devices and junction securement devices should be in accordance with manufacturers' guidelines (MHRA, 2005a; MHRAa, 2007).
- When add-on devices are used, they should be changed with each cannula or administration set replacement, or whenever the integrity of either product is compromised, and according to manufacturer recommendations (Pratt *et al.*, 2007; Finlay, 2008).

4.2 Splints

Standard

A splint should be used when the catheter is placed in or adjacent to an area of flexion or is at risk of dislodgement (INS 2006; Weinstein, 2007; Finlay, 2008).

Guidance

- A device specifically designed for splinting should be used to facilitate infusion delivery only when the device is placed in or around an area of joint flexion, for example the wrist, elbow or foot (Weinstein, 2007; Dougherty, 2008a).

- A splint can be used when the device is at risk of dislodgement, for example when it is being used on a child (Bravery, 2008) or an unco-operative or disorientated patient (Weinstein, 2007; Finlay, 2008) or when undue motion or excessive movement could lead to infiltration or phlebitis (Weinstein, 2007).
- A protocol for the use of splints should be set out in organisational policies, procedures and practice guidelines. Only splints designed specifically for use with IV therapy should be used and be appropriate to the age and needs of the patient.
- Any splint used should not impede any evaluation of the site and should be removed periodically for assessment of circulatory status (INS, 2006).
- Reusable splints and immobilisation devices should be decontaminated in line with local policy and manufacturers' guidance or be provided as a single use item.
- The correct type of splint should be used depending on the site of flexion, for example the elbow or wrist, to ensure the extremity remains in a functional position (Weinstein, 2007).
- Use of a splint should be included in the patient's care records.

4.3 Filters

Standard

All infusion sets should contain in-line filtration appropriate to the solution being administered.

Clear fluids require 15 micron filtration (or less) which is usually provided by a standard clear fluid set (Finlay, 2008).

For non-lipid-containing solutions that require filtration, an additional 0.2 micron filter containing a membrane that is both bacteria/particulate-retentive and air-eliminating should be used (INS, 2006; Finlay, 2008).

For lipid infusions or total nutrient preparations that require filtration, a 1.2 micron filter containing a membrane that is both bacteria/particulate-retentive and air-eliminating should be used (INS, 2006; Weinstein, 2007).

In-line blood component filters (integral mesh filter 170–200µm pore size), appropriate to the therapy, should be used to reduce particulate matter and microaggregates in infusions of blood components (RCN, 2005b; INS, 2006; McClelland, 2007).

Guidance

- Indications and protocol for the use of bacteria/particulate-retentive, air-eliminating, and blood and blood component filters should be set out in local organisational policies and procedures (INS, 2006).
- Use of filters should adhere to the manufacturer's guidelines and the filtration requirements of the therapy.
- Bacteria/particulate-retentive and air-eliminating membrane filter changes should coincide with administration set changes.
- Blood and blood component filters should be changed at least every 12 hours and after completion of the blood transfusion (RCN, 2005b; McClelland 2007).
- Add-on filters should not be used routinely for infection prevention purposes (Pratt *et al.*, 2007).
- In-line bacteria/particulate-retentive, air-eliminating membrane filters should be located as close to the catheter insertion site as possible (INS, 2006).
- Filter needles or straws should be used for drawing up medications from glass ampoules (INS, 2006).

4.4 Flow control devices

4.4.1 Manual flow control devices

Standard

The rate of infusions can be routinely regulated by manual flow control devices to ensure accurate delivery of the prescribed therapy.

The health care professional responsible for monitoring the patient should be accountable for the use of manual flow control infusion devices (Quinn, 2008).

Guidance

- Protocols for the use of manual flow control devices should be set out in organisational policies and procedures.
- Use of manual flow control devices should adhere to manufacturers' guidelines; these devices include, but are not limited to slide, roller clamps and drop controllers.
- Manual flow control devices may be used to regulate simple low-risk infusion (MDA, 2003). When selecting an infusion device consideration should be given to the patient's age and condition, prescribed therapy and the care setting in which the therapy is delivered (Quinn, 2008; Sarpal, 2008).
- A manual flow control device should achieve accurate delivery of the prescribed therapy with minimal deviation from manufacturers' guidelines.
- The nurse should demonstrate knowledge and competency related to manual flow control devices, including indications for use and ability to calculate flow rates (NMC, 2008a; Sarpal, 2008).
- Manual flow control devices should be considered as an adjunct to nursing care and are not intended to alleviate the nurse's responsibility for regularly monitoring and documenting the infusion rate of the prescribed therapy.
- Frequency of flow rate monitoring should be performed depending on the patient's clinical requirements (MDA, 2003).

4.4.2 Electronic flow control devices

Standard

Electronic infusion devices should be used in accordance with the MHRA risk classification system (MDA, 2003) that includes neonatal/paediatric use, patient condition, care setting and prescribed therapy.

The health care professional should demonstrate knowledge and competency which has been assessed relative to electronic infusion devices, and is responsible for monitoring the patient and is accountable for the use of electronic flow control infusion devices (NMC, 2008a; NMC, 2008b).

Electronic flow control infusion devices should be standardised throughout the organisation (MDA, 2003; NPSA, 2003).

Guidance

- Protocols for the use of electronic infusion devices should be set out in organisational policies and procedures.
- Manufacturers' guidelines should be adhered to in the use of electronic infusion devices; consideration should be given to electrical safety in the use of these devices.
- The safety features of the equipment should be of prime consideration in the selection of electronic infusion devices. Safety features include, but are not limited to, audible alarms, battery life and operation indicators, anti-free-flow protection, adjustable occlusion pressure levels, accuracy of delivery indicator, drug dosage calculation, in-line pressure monitoring and anti-tampering mechanisms (Pickstone, 2000; MDA, 2003).
- Electronic infusion devices should generate flow under positive pressure. These devices include, but are not limited to, peristaltic, syringe and pulsatile pumps (Quinn, 2008).
- The frequency of preventive maintenance of electronic infusion devices should be established in organisational policies and procedures, and should adhere to the manufacturer's guidelines and those established by the MHRA. The establishment of an equipment library is also recommended (MDA, 2003; NPSA, 2003).
- Information on how to decontaminate infusion devices prior to return to equipment libraries must be available.
- It is recommended that the following information is recorded: date, time infusion started, expected completion time, route, device serial number, rate setting, volume to be infused, total volume infused, volume remaining, checks of infusion site and rationale for any alterations (MDA, 2003).
- The nurse should demonstrate knowledge and competency which has been assessed relative to electronic infusion devices, including indications for use, programming the device to deliver the prescribed therapy, mechanical operation, the use of lock-out safety devices, troubleshooting, pounds per square inch (PSI) rating, the recommended height of the device, monitoring and safe use (Pickstone, 2000; Quinn, 2000; Murray and Glenister, 2001; MDA, 2003; DH, 2004a; INS 2006; Sarpal 2008).
- When an electronic infusion device is indicated to administer a vesicant medication, a low-pressure device should be chosen.
- When an electronic infusion device is indicated for an arterial access device, a high-pressure device should be chosen.
- When an electronic infusion device is used to administer high-risk drugs, a device with anti-free-flow protection should be chosen.
- Electronic infusion devices should be used for central venous access device infusions wherever possible.
- Electronic infusion devices should always be used where infusions are to be administered in paediatric patients due to the need for pressure monitoring and rapid occlusion alarms (Bravery, 2008).
- Electronic infusion devices should be considered an adjunct to nursing care and are not intended to alleviate the nurse's responsibility for regularly monitoring and documenting the infusion rate of the prescribed therapy.

4.5 Blood/fluid warmers

Standard

Devices used for blood/fluid warming must be specifically designed for that purpose to prevent haemolysis (INS, 2006; Bishop, 2008; Hanvey, 2008).

Guidance

- Protocols for the use of blood/fluid warmers must be set out in organisational policies and procedures and in accordance with the standards for administration of blood.
- The nurse should demonstrate knowledge of appropriate use and operation of specifically designed blood/fluid warmers (NMC, 2008b).

- Blood/fluid warmers must be used when warranted by patient history and/or prescribed therapy (McClelland, 2007; Bishop, 2008).
- Blood warmers should be used in the following situations: adults receiving infusion of blood at rates >50 ml/kg/hour; children at rates >15 ml/kg/hour; exchange transfusion of infants; and transfusing a patient who has clinically significant cold agglutinins (BCSH, 2004; Bishop, 2008).
- Blood warmers must be correctly maintained and used according to the manufacturer's instructions (McClelland, 2007).
- Blood must not be warmed by any other method, for example microwave oven (RCN, 2005b; McClelland, 2007).
- Blood/fluid warmers should undergo routine quality control inspections and be equipped with warning systems including an audible alarm and visual temperature gauges (INS, 2006).

4.6 Injection and access caps/ports

Standard

Injection and access caps/ports (which include injection caps, needle-free caps, catheter hubs or administration ports integral to an administration set) must be decontaminated using aseptic technique prior to accessing (NICE, 2003; MHRA, 2005a; Kaler and Chinn, 2007; MHRA, 2008c).

A safety device system, for example a needle-free system, is the preferred method of accessing injection and access caps/ports.

When accessing injection and access caps/ports it must be accomplished by using the smallest gauge, shortest needle that will accommodate the prescribed therapy (Finlay, 2008).

Injection and access caps/ports which are not integral to the device should be changed at established intervals according to manufacturers' instructions, or immediately if the integrity of the access site is compromised or if residual blood remains within the access site (MHRA, 2005a).

Injection and access caps/ports that are not integral to the device should be of Luer-Lok™ design (INS, 2006).

Guidance

- Protocols for disinfecting, accessing and changing of injection and access caps/ports should be set out in organisational policies and procedures and should be in accordance with the manufacturer's guidelines (NICE, 2003; MHRA, 2005a; Pratt *et al.*, 2007).
- To prevent the entry of micro-organisms into the vascular system, the injection access site should be decontaminated with an approved single-use antimicrobial solution, such as chlorhexidine in alcohol (unless contraindicated by manufacturers' recommendations). The solution should be applied with friction and allowed to dry, immediately before and after use (NICE, 2003; MHRA, 2005a; Kaler and Chinn, 2007; Pratt *et al.*, 2007).
- If a needle must be used, it should be between 25 and 21 gauge and not exceed one inch (2.5cm) in length. A needle smaller than 25 gauge should not be used (Finlay, 2008; Hopwood, 2008).
- The integrity of the injection and access caps should be confirmed before and immediately after each use. If the integrity of the injection or access cap is compromised, it should be replaced immediately, and consideration should be given to changing the device and/or administration set (MHRA, 2005a).
- Under no circumstances should devices be left with caps open or exposed.
- The optimal interval for changing injection and access caps/ports on central, peripherally inserted central and midline catheters should be in accordance with manufacturers' recommendations (MHRA, 2005a).
- Any time an injection access site is removed from a vascular access device, it should be discarded and a new sterile injection access site should be attached (MDA, 2000).

4.7 Tourniquet

Standard

A tourniquet should be properly applied to promote

venous distention and to impede venous but not arterial blood flow (Weinstein, 2007).

Guidance

- The tourniquet should be applied at an appropriate location proximal to the selected insertion site (Weinstein, 2007; Dougherty, 2008a; Witt, 2008).
- A pulse should be easily palpable distal to the tourniquet location (Camp Sorrell, 2004; INS, 2006; Weinstein, 2007).
- The tourniquet must not be applied for an extended period of time in order to prevent circulatory impairment (Dougherty, 2008).
- The tourniquet material should be considered with regard to potential latex allergy (INS, 2006).
- The tourniquet must be single patient use where there is the potential for microbial cross-contamination between patients (Golder *et al.*, 2000).
- Organisations should consider how tourniquets are managed in order to enable decontamination between each patient use. The use of fabric tourniquets which cannot be cleaned should be discouraged.
- The tourniquet should be a quick-release model which allows one-handed use (Dougherty, 2008).

4.8 Administration sets

4.8.1 Primary and secondary solution administration sets (continuous infusion)

Standard

Primary and secondary solution administration sets used for a continuous infusion must be changed every 72 hours and immediately upon suspected contamination or when the integrity of the product or system has been compromised (NICE, 2003; Pratt *et al.*, 2007).

Primary and secondary administration sets must be changed using aseptic technique, observing standard precautions and following manufacturers' recommendations (INS, 2006; Pratt *et al.*, 2007).

Only recommended or designated administration sets should be used in electronic infusion devices (MDA, 2003; Quinn, 2008).

Date and time labels must be applied to ensure administration sets are changed at the correct interval (Hopwood, 2008).

Guidance

- Protocols for primary and secondary continuous administration set changes must be set out in organisational policies and procedures (Gillies *et al.*, 2004; INS, 2006).
- Product integrity must be ascertained prior to use of the administration set.
- The primary administration set change should coincide with peripheral catheter change and/or initiation of a new container of solution. The secondary administration set change should coincide with change of the primary administration set and/or initiation of a new container of solution.
- Changing of add-on devices such as, but not limited to, extension sets, filters, stopcocks, and needle-less devices where possible should coincide with the changing of the administration set.
- The type of solution administered via a primary or secondary continuous administration set (for example parenteral nutrition, lipids, blood and blood components) should dictate whether the administration set is changed more frequently (Pratt *et al.*, 2007).
- Once a secondary administration set is detached from the primary administration set it should be discarded (Pratt *et al.*, 2007).
- Care must be taken to avoid backtracking when more than one IV set is connected through a single access point (MHRA, 2007a).

4.8.2 Primary intermittent solution sets

Standard

Primary intermittent administration sets should be changed every 24 hours if remaining connected to a device or discarded after each use if disconnected. The set should be disconnected immediately upon suspected contamination and discarded when the integrity of the product or system has been compromised (INS, 2006; Hopwood, 2008).

Primary intermittent administration sets must be changed using aseptic technique and observing standard precautions (Pratt *et al.*, 2007).

Date and time labels must be applied to ensure administration sets are changed at the correct interval (Hopwood, 2008; NPSA, 2007b).

Guidance

- Protocols for primary intermittent administration set changes should be set out in organisational policies and procedures (INS, 2006).
- Product integrity should be ascertained prior to use of the administration set.
- Change or add-on devices such as, but not limited to, extension sets, filters, stopcocks, and needleless devices where possible should coincide with the changing of the administration set.

4.8.3 Parenteral nutrition

Standard

Administration sets used for parenteral nutrition (PN) should be changed every 24 hours or immediately upon suspected contamination or when the integrity of the product or system has been compromised (Pratt *et al.*, 2007). However, if the solution contains only glucose and amino acids, administration sets in continuous use do not need to be replaced more frequently than every 72 hours (INS, 2006; Pratt *et al.*, 2007).

PN administration sets should be changed using aseptic technique and observing standard precautions (Pratt *et al.*, 2007).

Guidance

- Protocols for PN administration set changes should be set out in organisational policies and procedures (INS, 2006).
- Product integrity should be ascertained prior to use of the administration set.
- Changing of add-on devices such as, but not limited to, extension sets, filters, stopcocks, and needleless devices where possible should coincide with the changing of the administration set.

4.8.4 Blood and blood components

Standard

A sterile blood administration set should be used with a screen filter. It must be changed when a transfusion episode is complete or every 12 hours (whichever is sooner) or according to manufacturers' recommendations. A new administration set should be used if another fluid is to be infused following the blood components (RCN, 2005b; McClelland, 2007; Pratt *et al.*, 2007).

Administration sets used for blood components must be changed immediately upon suspected contamination or when the integrity of the product or system has been compromised (INS, 2006).

Administration sets used for blood components must be changed using aseptic technique and observing standard precautions, in line with manufacturers' instructions (Pratt *et al.*, 2007).

Guidance

- Protocols for blood and blood component administration set changes should be set out in organisational policies and procedures.
- Product integrity should be ascertained prior to use of the administration set.
- In-line blood and blood component filters appropriate to the therapy should be used.

4.8.5 Haemodynamic and arterial pressure monitoring

Standard

The disposable or reusable transducer and/or dome and other components of the system, including the administration set, continuous flush device and the flush solution used for invasive haemodynamic pressure monitoring, are considered a closed system and must be changed every 72 hours or sooner if contamination is suspected or when the integrity of the product or system has been compromised (Lai, 1998; Ciano, 2001; CDC, 2002; Pratt *et al.*, 2007).

The equipment should be changed using aseptic technique and observing standard precautions (Pratt *et al.*, 2007).

All administration sets should be of Luer-Lok™ design (INS, 2006).

Date and time labels must be applied to ensure administration sets are changed at the correct interval (Hopwood, 2008).

Guidance

- Protocols for haemodynamic and arterial pressure monitoring set changes should be set out in organisational policies and procedures.
- Product integrity should be ascertained prior to use of the haemodynamic monitoring system.
- Arterial administration sets must be labelled to prevent inadvertent drug administration (Scales, 2008a).
- Haemodynamic monitoring set changes should coincide with the initiation of a new container of solution or catheter.
- Changing of add-on devices such as, but not limited to, extension sets, filters, stopcocks and needle-less devices where possible should coincide with the changing of the haemodynamic monitoring set.

5

Site selection and placement

5.1 Site selection

Standard

Site selection for vascular access should include assessment of the patient's condition, age and diagnosis; vascular condition; infusion device history; and the type and duration of the therapy as well as the potential complications associated with vascular access devices (Wise *et al.*, 2001; Dougherty, 2006; Gabriel, 2008; Scales, 2008a).

The vasculature should accommodate the gauge and length of the device required by the prescribed therapy (Camp Sorrell, 2004; Scales, 2005; Dougherty and Watson, 2008).

Prior to peripherally inserted central catheter (PICC) insertion, anatomical measurements should be taken to determine the length of the catheter required to ensure full advancement of the catheter to achieve catheter tip placement in the superior vena cava/right atrium (Wise *et al.*, 2001; Lum, 2004).

Placement of any vascular access device, particularly central vascular access devices, is an aseptic procedure that should only be undertaken by staff who have had appropriate training (Pratt *et al.*, 2007; NMC, 2008b).

General guidance

- Criteria for site selection should be set out in organisation policies and procedures (INS, 2006).
- Site selection should be determined in line with the manufacturer's guidelines for insertion (Hamilton, 2000).

Peripheral devices: cannulae and midline catheters

- Veins that should be considered for peripheral cannulation are those found on the dorsal and ventral surfaces of the upper extremities including the metacarpal, cephalic and basilic (Griffiths, 2007; Dougherty, 2008a; Scales, 2008a).

- Veins in the lower extremities should not be used routinely in adults due to the risk of embolism and thrombophlebitis (Dougherty and Watson, 2008; Scales, 2008a). Patients with diabetes must not be cannulated in their feet.
- Site selection should involve assessment for previous venepuncture and subsequent damage to the vein (Dougherty, 2008a).
- Site selection should be routinely initiated in the distal areas of the upper extremities; subsequent cannulation should be made proximal to the previously cannulated site (Weinstein, 2007).
- Choice of an alternative site due to infiltration/extravasation of solutions into the extremity should require assessment of the type of solution, its pH, osmolarity, the estimated volume of the infusate and the condition of the vein (INS, 2006).
- Site selection should avoid areas of flexion (Dougherty and Watson, 2008) although this may not always be possible in an emergency situation such as during resuscitation when the antecubital fossa is recommended (Handley *et al.*, 2005).
- Arterial flow should not be compromised when pressure is applied to produce venous distension (Dougherty, 2008a).
- Blood pressure cuffs and tourniquets should not be used on an extremity where a peripheral device has been placed (INS, 2006).
- Cannulation of fistulae and grafts for infusion therapy requires the approval of a doctor. Alternatively, organisational policies and procedures must be followed (INS, 2006).
- Peripheral devices should not be routinely used for blood sampling but blood can be taken immediately following insertion (INS, 2006; Dougherty, 2008a).

- A relevant health care professional should be consulted, and the decision documented, prior to cannulation of the arm of a patient who has undergone mastectomy and/or axillary node dissection/radiotherapy or who may have existing fistulated access or other contraindications, for example, they require future fistula formation (Cole, 2006).
- Therapies which are not appropriate for certain peripheral cannulae and midlines include continuous vesicant chemotherapy, parenteral nutrition exceeding 10 per cent dextrose and/or 5 per cent protein, solutions and/or medications with pH less than 5 or greater than 9, and solutions and/or medications with osmolarity greater than 600mOsm/l (Camp Sorrell, 2004; INS, 2006).
- The cephalic, basilic or median cubital veins of the patient's arm can be used for the insertion of a midline catheter (Griffiths, 2007; Dougherty and Watson, 2008; Gabriel, 2008).
- Placement of the midline should be just above or below the fold of the antecubital area so as to aid the patient's comfort when flexing their arm. This will also minimise the potential for catheter kinking. With the use of ultrasound location, insertion may be placed higher up the arm.
- As the tip of the midline catheter does not extend beyond the axillary vein, X-ray confirmation of tip placement is not required prior to use (Camp Sorrell, 2004; INS, 2006; Griffiths, 2007).

Central venous access devices

- The cephalic, basilic or median cubital veins of the adult patient's arm can be used for the insertion of a PICC (Dougherty and Watson, 2008; Gabriel, 2008).
 - In neonates and children, the external jugular, axillary, long and short saphenous, temporal and posterior auricular veins can be used for PICC insertion (Bravery, 2008).
 - Ideally a PICC should be placed in the upper arm above the antecubital fossa (using ultrasound) so as to aid the patient's comfort when flexing their arm. This will also minimise the potential for
- catheter kinking. It can also be placed just above or below the fold of the antecubital area when ultrasound is not available.
- The choice of veins for non-tunnelled, tunnelled or implantable device cannulation should balance the risks for infection against the risks of mechanical complications and include the internal jugular, subclavian and femoral veins (Pratt *et al.*, 2007; Weinstein, 2007; Dougherty and Watson, 2008; Hamilton, 2009). Unless medically contraindicated, use the subclavian site in preference to the jugular or femoral sites for non-tunnelled catheter placement.
 - Use of 2D ultrasound imaging is recommended for all routine placements of central venous access devices using the internal jugular routes (NICE, 2002).
 - Central catheters should have the distal tip dwelling in the lower third of the superior vena cava or right atrium (Nightingale *et al.*, 1997; Wise *et al.*, 2001; Vesely, 2003; Chantler, 2009). The femoral vein should be used with caution for catheterisation. When using this route for tunnelled catheters the tip should dwell in the inferior vena cava (Gabriel, 2008).

Arterial catheters

- The most appropriate arteries for percutaneous cannulation are the radial, brachial and femoral.
- The most appropriate arteries for percutaneous cannulation are those which have a collateral circulation to preserve blood flow to the distal limb: this includes the radial artery (collateral flow from the ulnar artery) and the dorsalis pedis (collateral flow from the posterior tibial artery). The brachial and femoral arteries are used in practice but as neither has collateral flow, assessment of limb perfusion is essential (Scales, 2008a).
- When the radial artery has been selected for cannulation, an Allen's test should be performed to assess the circulation. Failure of the Allen's test precludes cannulation (INS, 2006; Scales, 2008a).

5.2 Device selection

Standard

The peripheral device selected should be the smallest gauge and shortest length that will be accommodated by the vein for the prescribed therapy for the individual patient (Camp Sorrell, 2004; Scales, 2005), and take into account the patient's lifestyle, preference, and therapy duration and setting (Dougherty, 2006).

The length of the central vascular access catheter will be selected in order to ensure that the distal tip of the catheter lies in the lower third of the superior vena cava or right atrium (Vesely, 2003, Dougherty, 2006, Gabriel, 2008).

A multiple-lumen device will not be routinely placed unless the patient's condition/intended treatment necessitates one (Pratt *et al.*, 2007).

All catheters must be radiopaque (Dougherty, 2006).

General guidance

- The nurse should have the necessary knowledge and competence to select the most appropriate device for the patient and the intended therapy. This should include: knowledge of the product in regard to insertion technique, potential complications, appropriateness to prescribed therapy and manufacturers' guidelines (Dougherty, 2006).
- The type of device inserted should be dependent on the length of therapy, the type of medication, the patient's condition and preference (Dougherty, 2006; Gabriel, 2008).
- Central venous catheters should be of single-lumen configuration unless additional therapies are required (Pratt *et al.*, 2007).

Peripheral devices

- A **peripheral cannula** is defined as one that is less than or equal to 3 inches (7.5cm) in length (INS, 2006; Dougherty and Watson, 2008). Peripheral cannulae should be selected for short-term therapy of 3–5 days and for bolus injections or short infusions in the outpatient/day unit setting (Dougherty and Watson, 2008).
- A **midline catheter for adults** is defined as one that is between 3 and 8 inches (7.5cm–20cm) in length (INS, 2006; Dougherty, 2008a). Midline

catheters are used where patients present with poor peripheral venous access and when the use of a central venous catheter is contraindicated. The midline catheter provides venous accessibility along with an easy, less hazardous insertion at the antecubital fossa (Goetz, 1998; Griffiths, 2007; Weinstein, 2007).

- Therapies not appropriate for peripheral cannulae and midlines include: continuous vesicant chemotherapy, parenteral nutrition exceeding 10 per cent dextrose and/or 5 per cent protein, solutions and/or medications with pH less than 5 or greater than 9, and solutions and/or medications with osmolarity greater than 600mOsm/l (Camp Sorrell, 2004; INS, 2006).
- Ideally, peripheral devices should be equipped with a safety device with engineered sharps injury protection. Local risk assessments should be undertaken concerning the use of these devices to reduce needlestick injuries and to monitor infection rates (Pratt *et al.*, 2007).
- The use of winged infusion devices should be limited to bolus injections of non-vesicant drug administration (CDC, 2002).

Central venous access devices

- A **peripherally inserted central catheter (PICC)** is a catheter that is inserted via the antecubital veins in the arm and is advanced into the central veins, with the tip located in the superior vena cava (usually the lower third) (INS, 2006).
- A **short-term central venous catheter** is a device that enters the skin directly into a central vein (Dougherty and Watson, 2008).
- Antimicrobial central venous catheters should be considered in high-risk patients to minimise the risk of catheter-related bloodstream infection (Pratt *et al.*, 2007).
- A **skin-tunnelled catheter** is a long-term catheter that lies in a subcutaneous tunnel before entering a central vein (Dougherty and Watson, 2008; Ives, 2009).
- An **implanted port** is a totally implanted vascular access device made of two components: a reservoir with a self-sealing septum which is attached to a silicone catheter (Dougherty and Watson, 2008; Ives, 2009).

- The port or reservoir of an implanted venous access device may produce minimal computed tomography (CT) or magnetic resonance (MR) artefacts. Consideration should therefore be given to the placement of plastic ports (Camp Sorrell, 2004; Weinstein, 2007).

Arterial access devices

- An arterial access device is a device placed in an artery (Scales, 2008a).
- Arterial access devices may be purpose-designed with end and side holes to maximise blood flow to the organ or limb in which the device is situated.
- Alternatively, short venous catheters are often placed in the radial artery to facilitate short-term arterial catheterisation for haemodynamic monitoring.
- Longer devices are used for femoral artery catheterisation due to the depth of subcutaneous tissue and range of movement of the hip joint.
- Arterial ports are increasingly being used for chemotherapy to target specific organs such as the liver and pancreas. Arterial devices are also used in vascular surgery and imaging procedures and are specific to the procedures being undertaken (Scales, 2008a).

5.3 Hair removal

Standard

Hair removal around the insertion site should be accomplished using scissors or clippers (Dougherty and Watson, 2008; Hart, 2008b).

Guidance

- Shaving with a razor should not be performed because of the potential for causing microabrasions, which increase the risk of infection (INS, 2006; Weinstein, 2007).
- Depilatories should not be used because of the potential for allergic reaction or irritation (INS, 2006).
- Electric clippers should have disposable heads for single-patient use (INS, 2006).
- Hair removal for the purpose of vascular assessment and site selection of the scalp of the neonate or paediatric patient should be performed with the consent of a person with parental responsibility for the child (DH, 2001d; Bravery, 2008).

5.4 Local anaesthesia

Standard

An injectable or topical local anaesthetic drug should be administered according to a patient-specific direction (prescription) or under a patient group direction (DH, 2006; NMC, 2008a).

When local anaesthesia is ordered or required, the agent which is least invasive and/or carries least risk for allergic reaction should be considered first (Moureau and Zonderman, 2000).

Guidance

- A protocol for the use of local anaesthesia should be established in organisational policies and procedures (INS, 2006).
- The nurse administering the local anaesthesia should have demonstrated competency and knowledge of the drug, method of administration used and management of complications (Fry and Anholt, 2001; NMC, 2008a).
- Use of injectable anaesthetic should be monitored because of the potential for allergic reaction, tissue damage and inadvertent injection of the drug into the vascular system (BMA & RPS, 2008).
- Local anaesthetics should not be injected into inflamed or infected tissues (BMA and RPS, 2008).
- Other types of local anaesthesia, such as iontophoresis or topical transdermal agents, should be considered and used according to organisational policies and procedures, and manufacturers' guidelines (Brown and Larson, 1999; Moureau and Zonderman, 2000; Spiers *et al.*, 2001; Fetzer, 2002; Galinkin *et al.*, 2002; Lander and Weltman, 2006).

5.5 Insertion site preparation

Standard

Prior to peripheral, midline, arterial, central and peripherally inserted central catheter placement insertion, the intended site should be decontaminated with the appropriate antimicrobial solution using aseptic technique (INS, 2006; Pratt *et al.*, 2007; Dougherty & Watson 2008).

General guidance

- Protocols for site preparation should be set out in organisational policies and procedures.
- Antimicrobial solutions in a single-unit-use configuration should be used wherever possible (Pratt *et al.*, 2007).
- Antimicrobial solutions that should be used include 2% chlorhexidine as a single agent or in combination (Maki *et al.*, 1991; Pratt *et al.*, 2007).
- Skin should be rubbed for approximately 30 seconds with the antimicrobial disinfection solution in order to decontaminate the skin effectively.
- The antimicrobial preparation solution(s) should be allowed to air-dry completely (at least 30 seconds) before proceeding with the vascular access device insertion procedure (Pratt *et al.*, 2007).
- Clipping should be performed to remove excess hair at intended vascular access site when necessary (INS, 2006; Weinstein, 2007).
- Powder-free gloves should be used (Pratt *et al.*, 2007).
- If using ANTT then non-sterile gloves can be worn for peripheral and central venous access device management as long as there is no necessity to touch the key parts of the procedure directly (Rowley and Laird, 2006).

Peripheral cannulae

- Decontaminate the site using a 2% chlorhexidine in alcohol solution for a minimum of 30 seconds (DH, 2007d).

Midlines and central venous access devices

- Maximum barrier precautions including sterile gown, sterile gloves and large sterile drapes should be used for arterial, central and peripherally inserted central catheter insertions in order to minimise the risk of infection to the patient (Pratt *et al.*, 2007; Hart, 2008b).
- 2% chlorhexidine in alcohol solution should be used to decontaminate the site. For patients with chlorhexidine sensitivity use single-use application of alcoholic povidone iodine solution (Pratt *et al.*, 2007).
- After initial site preparation, unless the skin decontamination process involves a non-touch technique, sterile gloves should be changed prior to midline, arterial, central and peripherally inserted central catheter placement (INS, 2006).

5.6 Device placement

Standard

All vascular access device placements should be for definitive therapeutic and/or diagnostic purposes (Hamilton, 2000).

Aseptic technique must be used and standard precautions should be observed during vascular access device placement (INS, 2006). This includes the appropriate use of hand hygiene and glove selection/use.

The vascular access device selected should be the smallest gauge which will accommodate the prescribed therapy (Camp Sorrell, 2004; Dougherty & Watson 2008).

Only one vascular access device should be used for each cannulation attempt (MDA, 2000; INS, 2006).

The distal tip of a central venous access device should dwell in the lower third of the superior vena cava and catheter tip location should be determined radiographically and documented in the patient's medical record prior to initiation of the prescribed therapy (Wise *et al.*, 2001; Vesely, 2003; Dougherty, 2006).

Guidance

- Protocols for the placement of vascular access devices should be set out in organisational policies and procedures.
- The nurse placing any vascular access device should have a comprehensive understanding of anatomy and physiology, vascular assessment techniques and insertion techniques appropriate to the specific device (Sansivero, 1998; Hamilton, 2000; Gabriel 2008).
- The nurse should inspect the vascular access device for product integrity prior to insertion (Dougherty, 2008a).
- Caution should be employed when stylets, needles and/or wires are used to facilitate vascular access device placement because of the risk of needlestick injury (Hart, 2008b).
- Stylets which are part of the catheter product should never be reinserted due to the risk of severing and/or puncturing the catheter (Dougherty, 2006; INS, 2006).
- The manufacturer's guidelines for product use should be followed in the preparation and placement of vascular access devices, including modifications made to the catheter tip (Hamilton, 2000).
- Peripheral and central vascular access device placement, including gauge and length, product name, batch and lot number, number of attempts, anatomical location and patient's response to the placement, should be documented in the patient's nursing and medical notes (INS, 2006).
- Radiological confirmation of the tip location should be obtained in the following clinical situations: prior to use of the central vascular access device; difficulty with catheter advancement; pain or discomfort after catheter advancement; inability to obtain positive aspiration of blood; inability to flush the catheter easily; difficulty in removing guidewire or guidewire bent on removal (Wise *et al.*, 2001; INS, 2006).

5.7 Device stabilisation

Standard

Devices should be stabilised in a manner that does not interfere with assessment and monitoring of the access site, that does not impede delivery of the prescribed therapy, and that is acceptable to the patient.

Device stabilisation should be performed using aseptic technique (Maki, 2002; Dougherty, 2006; Pratt *et al.*, 2007).

Stabilising devices should be placed so as not to impede circulation or impede infusion through the access device (Dougherty, 2006; Pratt *et al.*, 2007).

Guidance

- Protocols for stabilisation of the catheter should be set out in organisational policies and procedures.
- When a catheter securement device is used for stabilisation, placement should be in accordance with manufacturers' guidelines (Schears, 2005).
- Products employed to stabilise the peripheral cannula or midline or central venous catheter include sterile tapes, transparent semi-permeable membrane (TSM) dressing, sutures, manufactured catheter securement devices, and sterile surgical strips (Gabriel, 2001; Dougherty, 2006; Pratt *et al.*, 2007; Gabriel, 2008).
- When sterile tape is used, it should be applied only to the cannula or catheter hub and should not be applied directly to the cannula or catheter-skin junction site (Heckler, 2005).
- When using a TSM dressing for stabilisation, the manufacturer's guidelines for use should be followed and only sterile tapes should be used beneath the dressing, if required (Heckler, 2005; Dougherty, 2006).
- Sutures should not be routinely used for stabilisation of midlines, PICCs or non-tunnelled central vascular access devices due to their potential for contributing to the risk of infection (CDC, 2002; Maki, 2002; Heckler, 2005; Dougherty, 2006; Gabriel, 2008).

- A catheter which has migrated externally should not be re-advanced prior to re-stabilisation.
- Sutures used for tunnelled central catheter stabilisation may need to be replaced if they become loose or are no longer intact before the dacron cuff in the subcutaneous tunnel has fibrosed with surrounding tissue. Sutures should be removed at approximately 21 days; however, this may depend on certain factors such as age, skin condition and diagnosis (Dougherty, 2006; INS, 2006).
- Where sterile gauze dressings are used the site should be inspected and the dressing changed every 24 hours on peripheral and central venous catheter sites and immediately if the integrity of the dressing is compromised (NICE, 2003; Heckler, 2005; Dougherty, 2006; DH, 2007c; Pratt *et al.*, 2007).
- Sterile gauze used in conjunction with a TSM dressing should be treated as a gauze dressing and changed every 24 hours (Heckler, 2005).
- A TSM dressing on the peripheral cannula should be changed at the time of cannula resite and immediately if the integrity of the dressing is compromised (CDC, 2002).

5.8 Dressings

Standard

A sterile dressing must be applied and maintained on vascular and non-vascular access devices.

All dressings must be changed at established intervals in accordance with organisational policies/procedures, and immediately if the integrity of the dressing is compromised (CDC, 2002; Dougherty, 2006; Gabriel, 2006; Pratt *et al.*, 2007).

The insertion site must be assessed at least on a daily basis for the potential development of infusion-related complications (Dougherty, 2006; Gabriel, 2006).

Removal of site protection material should be done at established intervals, if a transparent dressing is not used, to allow visual inspection of the access site and monitoring of skin integrity in order to minimise the potential for infection (Dougherty, 2006; Pratt *et al.*, 2007).

Guidance

- Protocols for the use of sterile gauze and/or transparent semi-permeable membrane (TSM) dressings should be set out in organisational policies and procedures (Dougherty, 2006).
- The integrity of gauze dressing edges should be maintained with a sterile, occlusive material (Dougherty, 2006; INS, 2006; Pratt *et al.*, 2007).
- All central vascular access device dressings should be changed 24 hours after insertion or sooner if their integrity is compromised and thereafter as below (Ryder, 2001; Dougherty, 2006; Pratt *et al.*, 2007).
- For central venous access devices, the optimal time interval for changing TSM dressings will depend on the dressing material, age and condition of the patient, environmental conditions and manufacturers' guidelines, but they should be assessed at least on a daily basis, not remain in place longer than seven days (after initial 24 hour post-insertion dressing) and should be changed if the integrity of the dressing has been compromised (CDC, 2002; NICE, 2003; Dougherty, 2006; Pratt *et al.*, 2007).
- The insertion site should be visually inspected and palpated for tenderness at least daily through the intact dressing (Dougherty, 2006; Hart, 2008b).
- In the event of tenderness at the site, fever without an obvious source, symptoms of local or systemic infection, or the presence of exudate, the dressing should be removed and the site assessed (Pratt *et al.*, 2007).
- Documentation in the patient's nursing notes should reflect routine assessment and describe the condition of the insertion site.
- Patient education regarding dressing care and maintenance should be documented in the patient's notes.

6

Site care and maintenance

6.1 Site care

Standard

Vascular access device site care must be performed using aseptic technique and observing standard precautions, and should coincide with dressing changes (Dougherty and Watson, 2008).

When performing site care, observation and evaluation of the device and surrounding tissue, the integrity of the device and security of the connections should be checked and documented (DH, 2007c).

Guidance

- Protocols for vascular access device site care should be set out in organisational policies and procedures (INS, 2006).
- Where necessary, cleansing of the peripheral cannula site may be carried out at dressing change using an appropriate antimicrobial solution.
- Central venous catheter site care should consist of decontamination of the catheter skin junction with an appropriate antimicrobial solution and application of a sterile dressing (Pratt *et al.*, 2007) at least every seven days or as necessary depending on the type of dressing (see 5.7 and 5.8 for details).
- Antimicrobial solutions should be used in accordance with manufacturers' guidelines.
- Antimicrobial solutions that should be used for site care are 2% chlorhexidine, as a single agent or in combination with alcohol or aqueous solution (Pratt *et al.*, 2007). Where alcohol is used, check manufacturers' recommendations for any potential damage to catheter material.
- Following hand antisepsis, clean gloves and an aseptic technique or sterile gloves should be used performing site care for central venous access devices (Pratt *et al.*, 2007).

- Documentation of catheter site care should reflect the condition of the catheter site; specific nursing actions should be taken to resolve or prevent adverse reactions and interventions should be documented in the patient's medical record (DH, 2007c).
- When ports are accessed the non-coring needle should be changed every seven days (Camp Sorrell, 2004; Goodman, 2005; Dougherty, 2006; INS, 2006; Weinstein, 2007).

6.2 Maintaining patency

Standard

The patency of the device will be checked prior to administration of medications and/or solutions. However, there is no requirement to routinely withdraw blood and discard it prior to flushing (except prior to blood sampling). See 8.11 and Appendix 5.

The device should be flushed at established intervals to promote and maintain patency and to prevent the mixing of incompatible medications and/or solutions (NPSA, 2007b).

The patency of the device should be maintained using the correct techniques such as positive pressure and pulsatile flush.

Guidance

- The nurse should aspirate the device to check blood return to confirm patency prior to administration of medications and/or solutions (INS, 2006).
- In absence of blood return, an attempt should be made to flush the device; if resistance is met undue force should not be applied. For peripheral cannulae, it may be necessary to remove the device. For midlines and all central venous access devices, the nurse should take further steps to assess patency of the device prior to administration of medications and/or solutions (INS, 2006). The relevant algorithm should be followed for checking blood return from a central venous access device (see Appendix 5) and for further guidance in the community see Appendix 8.

- A nurse should routinely flush indwelling peripheral cannulae with sodium chloride 0.9% and open-ended central venous catheters with an anticoagulant when the device is not in regular use, unless advised otherwise by the manufacturer (Pratt *et al.*, 2007).
- It is usually recommended that pressure-activated valved catheters and some positive pressure flush devices are flushed with 0.9% sodium chloride (Camp Sorrell, 2004; INS, 2006; Pratt *et al.*, 2007).
- The volume of the flush solution should be equal to at least twice the volume of the catheter and add-on devices – usually 5–10 ml.
- The concentration of heparin should be the lowest possible that will maintain patency – usually 10iu heparin in 1 ml 0.9% sodium chloride (except with implanted ports which may require 100iu/ml heparin).
- Frequency of flushing should be daily for peripheral devices, 8-12 hourly for short-term central venous catheters and weekly for long-term central venous access devices, unless occlusive problems indicate otherwise (Kelly *et al.*, 1992; Dougherty and Watson, 2008) or every 4 weeks for an implanted port (Camp Sorrell, 2004).
- Flushing with 0.9% sodium chloride solution to ensure and maintain patency should be performed before, between and after the administration of incompatible medications and/or solutions (NICE, 2003; INS, 2006).
- The nurse should flush using a pulsated push-pause and positive pressure method. The pulsated flush creates turbulence within the device lumen, removing debris from the internal device wall (Goodwin and Carlson, 1993; Gabriel *et al.*, 2005). Positive pressure within the lumen of the device should be maintained to prevent reflux of blood (INS, 2006) using the correct technique or specially designed injection ‘positive pressure or positive displacement caps’ (Berger, 2000; Lenhart, 2000; Mayo, 2001b; Rummel *et al.*, 2001; Gabriel *et al.*, 2005).

6.3 Catheter clearance

Standard

The nurse should ascertain the cause of the occlusion – thrombotic, non-thrombotic or mechanical (Dougherty, 2006; Dougherty & Watson 2008).

The nurse should understand the predisposing factors and preventive strategies (Krzydwa, 1999).

6.3.1 Thrombotic occlusions

Thrombolytic agents specifically indicated for dissolving clots should be administered and must be prescribed or administered under patient group direction.

The instilled volume of thrombolytic agents should not exceed the volume capacity of the catheter.

6.3.2 Non-thrombotic occlusions

Agents specifically indicated for dissolving medication and/or solution precipitate should be administered and must be prescribed or administered under patient group direction.

The instilled volume of precipitate clearance agents should not exceed the volume capacity of the catheter.

6.3.3 Mechanical causes of occlusion

Kinking or pinch-off syndrome can impair the patency of the device and the nurse must have the knowledge to recognise early signs and act accordingly, for example order chest x-ray and/or remove the catheter (Dougherty, 2006).

Guidance

- Protocols for the use and contraindications of thrombolytic agents and precipitate clearance agents to restore catheter patency should be set out in organisational policies and procedures (INS, 2006).
- The health care professional using a thrombolytic agent or precipitate clearance agent should have knowledge of dosage, contraindications, side-effects and mechanism of instillation (Bagnell Reeb, 1998; NMC, 2008a).

- Thrombolytic agents specifically indicated for catheter clearance should be administered (Haire, 2000; Ponc *et al.*, 2001; Deitcher *et al.*, 2002; Timoney *et al.*, 2002).
- Use of these agents should adhere to manufacturers' guidelines.
- The nurse's responsibilities should include assessment for appropriateness of use, documentation of outcome and continued surveillance of the patient (Lenhart, 2000).
- Instillation, aspiration and flushing of vascular access devices should be performed using a method that is within the catheter manufacturer's maximum pressure limits in pounds per square inch (PSI).
- The syringe size used for this procedure should be in accordance with the catheter manufacturer's guidelines, as excessive pressure may cause complications such as catheter separation and/or rupture, resulting in loss of catheter integrity. It is recommended that a syringe smaller than 10 ml is **not** used (Conn, 1993).
- Should the procedure using these thrombolytic agents or precipitate clearance agents not restore catheter patency, the appropriate health care professional should be notified.
- Other methods such as endoluminal brushes could be considered (Archis, 2000).
- The procedure should be documented in the patient's medical and nursing notes (NMC, 2005).

6.4 Vascular access device removal

Standard

The removal of any vascular access device must only be undertaken by an appropriately trained practitioner. Those commonly removed by nurses include cannulas, midline catheters, PICCs and non-tunnelled CVCs.

General guidance

- Any vascular access device may be removed by a nurse in accordance with established organisational policies and procedures, provided that they have the appropriate experience, knowledge and skills (Dougherty and Watson, 2008).
- If removal is due to catheter-related infection the catheter tip should be sent to the microbiology laboratory for culture and antimicrobial sensitivity. This action should be documented in the patient's care records.

When the device is removed the tip should be checked to ensure it is intact and if the tip is not complete it should be reported and the appropriate patient observation and actions taken. It should also be documented in the patient's medical and nursing notes (Drewett, 2009; INS, 2006).

- Any device defect should be reported to the organisation's risk management department, the manufacturer, and the MHRA and NPSA.

Peripheral devices

- A peripheral cannula should be removed every 72-96 hours or sooner if complications are suspected and re-sited if still required (DH, 2007c).
- Document the reason for the removal and condition of the site, for example by using a scoring system such as the VIP scale to document evidence of phlebitis, see appendix 1.
- A peripheral cannula inserted in an emergency situation, where aseptic technique has been compromised, should be replaced within 24 hours.
- The optimal dwell time for removal of midline catheters is unknown; ongoing and frequent monitoring of the access site should be performed (CDC, 2002).
- A midline catheter should be removed if the tip location is no longer appropriate for the prescribed therapy.

Central vascular access devices

- The optimal dwell time for removal of PICCs, tunnelled catheters or implanted ports is unknown; ongoing and frequent monitoring of the access site should be performed (Drewett,

2009; INS, 2006).

- Caution should be used in the removal of central venous catheters, including precautions to prevent air embolism (patient should be lain flat with head down if tolerated). Digital pressure should be applied until haemostasis is achieved, then a sterile occlusive dressing should be applied to the access site upon catheter removal, and checked regularly to ensure it is intact. It should remain *in situ* for 72 hours after removal (Drewett 2009; Dougherty *et al.*, 2008; Scales, 2008a).
- If resistance is encountered when the catheter is being removed, the catheter should not be removed and the relevant health care professional should be notified immediately and/or local policies followed (Marx, 1995).
- Protocols for post-removal site assessment should be set out in organisational policies and procedures.
- After skin-tunnelled catheter or implanted venous access device removal, the wound should be kept dry for five to seven days, and where appropriate, the wound monitored until healed (Drewett, 2009).

Arterial catheters

- An arterial catheter inserted in an emergency situation where aseptic technique has been compromised should be replaced within 24 hours wherever possible (CDC, 2002).
- When a peripheral arterial catheter is removed, digital pressure should be applied until haemostasis is achieved (5 to 15 minutes), then a dry, sterile, pressure dressing should be applied to the access site (Ciano, 2001; Scales, 2008a).
- After the removal of the arterial catheter the peripheral circulatory status distal to the access site should be assessed and documented in the patient's records (Ciano, 2001; Scales, 2008a).

6.5 Catheter malposition

Standard

External catheters should be secured appropriately to prevent catheter malposition and associated complications (Dougherty, 2006).

If catheter malposition is suspected the catheter should not be used for the administration of medication, solutions or chemotherapy until the catheter tip position has been confirmed.

Guidance

- Catheter malposition may occur during insertion or days to months after insertion. Possible causes include vigorous upper extremity use, forceful flushing of the catheter, changes in intrathoracic pressure associated with coughing, sneezing, vomiting or constipation, congestive cardiac failure or catheter foreshortening, due to repair (Dougherty, 2006).
- Protocols for securing external catheters should be set out in organisational policies, procedures and practice guidelines (INS, 2006).
- Products employed to stabilise the catheter should include sterile tapes, transparent moisture-permeable dressings, sutures, manufactured catheter securement devices and sterile surgical strips. Whenever feasible, the use of a manufactured catheter securement device, e.g. Statlok™ is preferable (INS, 2006; Frey and Schears, 2006; Schears, 2006; Bishop *et al.*, 2007).
- When a catheter securement device is used for stabilisation, placement should be in accordance with manufacturers' guidelines (INS, 2006).
- When sterile tape is used, it should be applied only to the catheter adapter and should not be applied to the catheter-skin junction site (INS, 2006).
- When using a transparent moisture-permeable dressing for stabilisation, the manufacturer's guidelines for use should be followed; only sterile tapes should be used beneath the dressing if required.
- If sutures are used for catheter stabilisation, placement of sutures should be set out in organisational policies and procedures and

carried out in accordance with the manufacturer's guidelines and *The Code* (NMC, 2008b).

- If sutures become loose or are no longer intact, other measures should be implemented to prevent catheter migration or dislodgement (INS, 2006).
- A catheter which has migrated externally should not be readvanced prior to reestablishment (INS, 2006).
- External catheters should be secured with tape, sutures and an intact dressing (Hadaway, 1998).
- Use of tape and/or transparent dressing, plastic shields or adhesive anchoring devices (for example 'Statlock™') will reduce the risk of catheter dislodgement (Hanchett, 1999).
- The patient and/or caregiver should be instructed in ways of avoiding catheter dislodgement (Hadaway, 1998; Pratt *et al.*, 2007).
- The practitioner caring for the patient with a central venous access device should be knowledgeable about the complications of catheter dislodgement. These include occlusion, thrombosis, fibrin sheath, extravasation and vessel perforation if catheter tip is outside the superior vena cava (SVC) (Wise *et al.*, 2001).
- Clinical features of malposition include the catheter appearing longer at the exit site, the cuff being visible or lack of blood return. Catheter malposition may be asymptomatic; however, the following symptoms may suggest malposition on insertion or when *in situ*:
 - a) resistance or discomfort during insertion
 - b) bending in the guide wire when removed from the catheter
 - c) 'ear gurgling' experienced by the patient with catheter malposition in the internal jugular vein
 - d) arrhythmias when the tip is too far into the right atrium
 - e) partial or complete catheter occlusion
 - f) headache, chest/shoulder pain or back pain with infusion
 - g) reduced infusion rate
 - h) signs of extravasation
 - i) ipsilateral extremity oedema
 - j) backflow of blood into external tubing unrelated to increased intrathoracic pressure (Lamb and Dougherty, 2008; Bodenham & Simcock, 2009).
- To accurately confirm catheter dislodgement and catheter tip position a chest x-ray should be performed with an AP and lateral view (Dougherty, 2006; Markovich, 2006).
- Venogram studies may also be undertaken to confirm catheter malposition (Weinstein, 2007).
- If the catheter tip is outside the SVC the catheter should be repositioned, replaced or removed (Wise *et al.*, 2001).

6.6 Catheter exchange

Standard

Exchange should only be performed if there is no evidence of infection at the catheter site or proven bloodstream infection (Pratt *et al.*, 2007).

Midline catheters and PICCs can be exchanged over a guidewire and through a peelaway sheath introducer. A non-tunnelled central catheter can be exchanged over a guidewire only (Scales, 2008a).

Maximal barrier precautions should be observed during the exchange of the catheter following manufacturers' instructions (INS, 2006). Gloves should be changed after removing the old catheter and before touching the new catheter (CDC, 2002).

Guidance

- Protocols for exchanging midlines, PICCs and non-tunnelled central vascular access devices should be set out in organisational policies and procedures.
- The nurse undertaking the exchange of a catheter should have a comprehensive understanding of the technique involved for the particular device (INS, 2006) and the patient should be positioned as for catheter insertion to prevent air embolism (Scales, 2008a).

- The nurse should inspect the catheter for product integrity prior to placement.
- The manufacturer's guidelines for product use should be considered in the preparation and placement of the device.
- When the device is removed it should be checked to ensure it is intact and if it is not it should be reported and the appropriate patient observation and actions taken, and documented in the patient's medical and nursing notes (INS, 2006).
- Any defect in the retrieved catheter should be reported to the organisation's risk management department and the manufacturer, as well as the MHRA and NPSA (MHRA, 2008a).
- Radiographic confirmation of the correct tip location should be performed prior to using the catheter (INS, 2006).
- A record of the procedure should be recorded in the patient's medical and nursing notes (NMC, 2005).

6.7 Catheter repair

Standard

When the external portion of a vascular access device is damaged, the device must be repaired according to the manufacturer's guidelines, using aseptic technique and observing standard precautions (Reed and Phillips, 1996; INS, 2006; Gabriel, 2008).

The practitioner performing the repair should possess the requisite knowledge, skills, abilities and competence to undertake the procedure (NMC, 2008b).

The device should be removed if it cannot be repaired (INS, 2006; Bishop *et al.*, 2007).

The device repair should be documented in the patient record in accordance with the NMC standards for record keeping (NMC, 2005).

The patient and/or caregiver should be taught how to prevent damage occurring, how to recognise the signs of a damaged catheter and the complications which may result (for example air embolism, infection) and what action to take regarding the damaged catheter and prevention of complications (Bishop *et al.*, 2007; Pratt *et al.*, 2007; Weinstein, 2007).

Guidance

- Vascular access devices which can be repaired include midline catheters, PICCs and tunnelled central catheters (Reed and Phillips, 1996; Dougherty, 2006; INS, 2006; Gabriel, 2008).
- External repairs of damaged catheters can be performed using kits provided by the manufacturers (Bishop *et al.*, 2007; Gabriel, 2008).
- The position of the catheter damage will dictate whether the catheter can be repaired or will require removal (Dougherty, 2006).
- Damaged non-tunnelled catheters or single-lumen PICCs can be exchanged over a guide wire if there are no signs of infection (Dougherty, 2006).
- All catheter repairs must be performed by a registered nurse or practitioner who is educated and competent to perform the procedure (Reed and Phillips, 1996; INS, 2006).
- Assessment of the patient's risk/benefit ratio should be performed before repairing the device (Reed and Phillips, 1996; INS, 2006).
- Access device repair should be documented in the patient's medical and nursing notes (Reed and Phillips, 1996; INS, 2006; NMC, 2008b).
- An incident form should be completed and any defective devices should be reported to risk management, the manufacturer and the MHRA (MHRA, 2008a).

7

Specific devices

7.1 Intrapleural catheters

Standard

The insertion of an intrapleural catheter is a medical procedure.

Administration of medicines through an intrapleural catheter will be in accordance with a valid prescription and following local training to include recognition of side-effects that could occur if the catheter migrates from the pleural space (Hyde and Dougherty, 2008).

Removal of an intrapleural catheter will be performed in agreement with the doctor managing the patient's care and is usually a nursing procedure (INS, 2006).

Guidance

- The optimal dwell time for an intrapleural catheter is unknown; ongoing and frequent monitoring of the access site should be performed.
- An intrapleural catheter may be removed by a nurse in accordance with established organisational policies and procedures.
- Caution should be used in the removal of an intrapleural catheter. To prevent pneumothorax, digital pressure should be applied until haemostasis is achieved and a sterile occlusive dressing should be applied to the access site upon catheter removal.
- If resistance is encountered when the catheter is being removed, the catheter should not be removed and the doctor responsible for the patient's care should be notified.

7.2 Arteriovenous fistulae, shunts and haemodialysis catheters

Standard

The construction or removal of an arteriovenous (AV) fistula or shunt is considered to be a medical procedure.

The insertion of a haemodialysis catheter is usually a medical procedure in most hospitals but is a developing area of nursing practice.

Administration of medicines and/or solutions through an AV fistula, shunt or haemodialysis catheter will be in accordance with a valid prescription or patient group direction.

Removal of a haemodialysis catheter will be performed in agreement with the doctor managing the patient's care and is a nursing procedure.

Guidance

- The nurse should be educated and competent, according to organisational policies and procedures, to care for and maintain an AV fistula, shunt or haemodialysis catheter.
- AV fistulae, shunts and haemodialysis catheters should not be used for routine administration of parenteral medication and/or solutions (INS, 2006).
- Aseptic technique should be used for all procedures relating to haemodialysis access devices.
- To minimise the potential for catheter-related complications, consideration should be given to the gauge and length of the haemodialysis catheter.
- When removing the guidewire from the catheter, or removing the needle from the fistula, techniques should be employed to reduce the potential for bleeding and to promote haemostasis.

- Haemodynamic monitoring and venepuncture should not be performed on the extremity containing an AV fistula except in an emergency and where there is no alternative.
- Protocols for the removal of haemodialysis catheters should be set out in organisational policies and procedures and should be in accordance with manufacturers' guidelines.
- The optimal dwell time for a haemodialysis catheter is unknown; ongoing and frequent monitoring of the access site should be performed. Depending on the type of catheter, it will usually be removed at seven days. If it is not, it should be assessed every 24 hours thereafter until it is removed.
- The optimal dwell time for the removal of a non-tunnelled haemodialysis catheter is unknown; ongoing and frequent monitoring of the access site should be performed. Depending on the type of catheter and the clinical risk factors it will usually be removed at seven days. If it is not, it should be assessed every 24 hours thereafter until it is removed.
- The haemodialysis catheter will be removed immediately when contamination or a complication is suspected, or when therapy is discontinued.
- Radiographic confirmation should be obtained prior to the initiation of therapy.
- Caution should be used in the removal of a haemodialysis catheter, including precautions to prevent air embolism; digital pressure should be applied until haemostasis is achieved; then a sterile, occlusive dressing should be applied to the access site.
- The occlusive dressing should remain *in situ* for 72 hours to prevent delayed air embolism. The dressing should be assessed regularly during this time to ensure that it remains intact and effective (Scales, 2008a).

7.3 Cutdown surgical sites

Standard

Insertion of a vascular catheter via a cutdown surgical site should be performed by a clinician or health care professional with the appropriate skills and should not be used routinely (CDC, 2002).

Guidance

- Protocols regarding cutdown surgical sites, including catheter removal, should be set out in organisational policies and procedures (INS, 2006).
- Aseptic technique should be used and standard precautions should be observed when caring for a patient with a cutdown surgical site.
- Consideration should be given to the establishment of alternative vascular access prior to the removal of a cutdown access device (Scales, 2008a).

7.4 Intraosseous access

Standard

Intraosseous access should be obtained for emergency or short-term treatment when access by the vascular route is difficult or cannot be achieved and the patient's condition is considered life-threatening (adults and children) (Resuscitation Council UK, 2005; INS, 2006).

Intraosseous access by nurses should be initiated by a practitioner with the experience, knowledge and skills to undertake this procedure in accordance with NMC guidelines (NMC, 2008b).

Aseptic technique should be used and standard precautions should be observed for intraosseous access (INS, 2006; Weinstein, 2007).

Guidance

- Indications and protocols for the use of intraosseous access should be set out in organisational policies and procedures and practice guidelines (INS, 2006b).
- The nurse caring for a patient with an intraosseous access device should have knowledge of the principles involved in adult and/or paediatric fluid resuscitation; anatomy and physiology of the intraosseous route; potential complications; and patient/family education. The nurse should be educated and competent in intraosseous access (INS, 2006).
- The nurse's responsibilities should include site assessment, care and maintenance; discontinuation of access; and documentation (INS, 2006).
- Intraosseous access device placement is a temporary, emergency procedure, and the device should be removed within 24 hours, after appropriate access has been obtained (West, 1998; INS, 2006).
- Intraosseous ports (implanted intraosseous port i.e. Osteoport™, a 1 inch titanium or stainless steel needle with a self-sealing cap that can be implanted in a large bone of the hip or leg) should be removed within 30 days of insertion or immediately if complications develop (Weinstein, 2007).
- Conventional vascular access should be established as soon as the patient's condition has stabilised (Smith, 1998).
- Intraosseous access should not be attempted on sites where intraosseous access has been previously attempted, on a fractured or traumatised leg, on areas of infected burns or cellulitis, or on patients with osteoporosis, osteopetrosis or osteogenesis imperfecta (Manley, 1989; INS, 2006; Great Ormond Street Hospital (GOSH), 2007).
- Where possible drugs should be given intravascularly (intravenous or intraosseous), in preference to the tracheal route (children) (International Liaison Committee On Resuscitation (ILCOR), 2006; Resuscitation Council (UK), 2005).
- Intraosseous access is recommended for the administration of medications in children with cardiac arrest when no acceptable vascular access is available. The use of the intraosseous route extends to children of all ages (European Resuscitation Council, 2000).
- The preferred site for paediatric intraosseous access should be the anterior tibial bone marrow. Alternative sites include the distal femur, medial malleolus, or anterior superior iliac spine (American Heart Association and International Liaison Committee on Resuscitation, 2000; GOSH, 2007).
- The growth plate in children's bones should be avoided (Manley, 1989; INS, 2006; GOSH, 2007).
- If the intraosseous access method is indicated in adults, the preferred sites should be the iliac crest or sternum (INS, 2006). Use of the sternum may be associated with complications and may be impractical for patients receiving cardiopulmonary resuscitation or with significant chest trauma (Lavis, 1999).
- Access devices used to obtain 24-hour intraosseous access should include standard steel hypodermic, spinal, trephine, sternal and standard bone marrow needles (INS, 2006).
- Consideration should be given to the use of an access device with a short shaft to avoid accidental dislodgement (INS, 2006).
- Consideration should be given to the use of commercially prepared, disposable access equipment specifically designed for intraosseous infusions (INS, 2006).
- Prior to infusion, access device placement should be confirmed by aspiration of bone marrow followed immediately by a flush of preservative-free 0.9% sodium chloride solution (injectable) using a separate syringe (Smith, 1998; INS, 2006). If no marrow is aspirated but the needle is standing in a stable, unsupported position and loss of resistance was felt on entering the cortex then assume the intraosseous (I/O) needle is correctly sited and use accordingly (GOSH, 2007).
- The intraosseous access device should be secured to prevent migration and extravasation into the subcutaneous tissues (Smith, 1998; West, 1998).

- Fluid administered for rapid volume resuscitation may require the use of an infusion pump or forceful manual pressure (American Heart Association and International Liaison Committee on Resuscitation, 2000).
- The site should be observed for complications such as extravasation/infiltration, compartment syndrome, skin necrosis and infection (Frey, 2007; GOSH, 2007).
- The I/O needle should be removed by a practitioner with demonstrated competency, using aseptic technique and standard precautions (INS, 2006).
- Precautions to prevent air embolism should be employed when removing the I/O needle. After removal, digital pressure should be applied and antiseptic ointment applied and a sterile occlusive dressing. The site should be assessed every 24 hours until the site is epithelialised (INS, 2006).
- The condition of the site and integrity of the I/O needle should be determined on removal. This should be documented in the patient record (INS, 2006).
- If resistance is encountered on I/O needle removal, the device should not be removed and the doctor informed (INS, 2006).

7.5 Subcutaneous injection/infusion (hypodermoclysis)

Standard

The nurse must assess the patient for appropriateness and duration of the prescribed therapy (Hypodermoclysis Working Group, 1998).

Drug dose, volume, concentration and rate should be appropriate with regard to the integrity and condition of the patient's subcutaneous tissue (Hypodermoclysis Working Group, 1998).

Guidance

- Specific criteria should be set out in organisational policies and procedures for access site management, prescribed medication, rate of administration, availability of sites, required therapy, diagnosis, anticipated length of therapy and maintenance of the integrity of the subcutaneous tissue (Hypodermoclysis Working Group, 1998).
- The nurse should be educated and competent in the use of medications, solutions and subcutaneous administration procedures (Hypodermoclysis Working Group, 1998).
- Consideration should be given to the use of an electronic device – for example, a syringe driver – when administering medications via the subcutaneous infusion route (Hopwood, 2008).
- A standard administration set (20 drops per ml) should be used for the administration of fluids and solutions (hypodermoclysis) which should be gravity fed, not pumped (Hypodermoclysis Working Group, 1998).
- The selected access site should have intact skin and be located away from bony prominences, areas of infection, inflamed or broken skin, the patient's waistline, previously irradiated skin, sites near a joint and lymphoedematous limbs (Hypodermoclysis Working Group, 1998; Mitten, 2001; Hopwood, 2008).
- The access site should be prepared using aseptic technique and observing standard precautions (Hopwood, 2008).
- A sterile transparent occlusive dressing should be used to cover the administration site (Hypodermoclysis Working Group, 1998; Hopwood, 2008).
- To reduce the risk of complications, the subcutaneous access site should be observed regularly, rotated a minimum of every three days or if the patient complains of pain at the administration site, the skin is red and/or inflamed, the skin is white and/or hard, or blood is present in the administration set, plastic cannula or winged infusion device (Hypodermoclysis Working Group, 1998; INS, 2006; Hopwood, 2008).
- The device selected should be of the smallest gauge and shortest length necessary to establish subcutaneous access (Hypodermoclysis Working Group, 1998).

- Research has shown that using peripheral cannula, rather than steel winged infusion devices, results in the subcutaneous site remaining viable for longer (Torre, 2002).
- Consideration should be given to the use of additives that enhance absorption and diffusion of the medication or solution (Hypodermoclysis Working Group, 1998; Hopwood, 2008).
- The medication or solution should be as near to isotonic as possible (Hypodermoclysis Working Group, 1998).
- It is recommended that fluids containing electrolytes such as sodium chloride 0.9% or dextrose saline be used although dextrose 5% has been used (Nobel-Adams, 1995).
- Documentation in the patient's medical and nursing notes should include evaluation of the need for subcutaneous infusion, patient response to therapy, and the established intervals of monitoring the infusion site (Hypodermoclysis Working Group, 1998).

7.6 The Ommaya reservoir (an intraventricular access device)

Standard

Drugs for administration via an Ommaya reservoir should be prepared and administered using aseptic technique and standard precautions (Camp Sorrell, 2004; Weinstein, 2007).

Protective clothing should be used when preparing and administering intraventricular chemotherapy via an Ommaya reservoir (Management and Awareness of Risks of Cytotoxic Handling (MARCH), 2007; Hyde, 2008a).

The practitioner administering intraventricular therapy via an Ommaya reservoir should be knowledgeable about the indications for therapy, the side-effects of drugs administered via this route, and the complications of use of an Ommaya reservoir. The practitioner should be trained and assessed as competent to perform the procedure (NMC, 2008b).

Measures should be taken to minimise the risk of complications of using an Ommaya reservoir.

Chemotherapy administered using an Ommaya reservoir must be administered in accordance with the *National guidance on the safe administration of intrathecal chemotherapy* as this includes drugs delivered by lumbar puncture and other routes, for example Ommaya reservoirs (DH, 2008).

Guidance

- All NHS trusts where chemotherapy is administered via an Ommaya reservoir must ensure full implementation of and adherence to the *National guidance on the safe administration of intrathecal chemotherapy* (DH, 2008).
- Protocols for the administration of drugs via an Ommaya reservoir should be established in organisational policies, procedures and practice guidelines (INS, 2006).
- Drugs to be administered via an Ommaya reservoir must be prepared and administered using aseptic technique and be free of preservatives (Camp Sorrell, 2004; INS 2006).
- Alcohol, disinfectants containing alcohol or acetone should not be used for site preparation as they are neurotoxic (West, 1998; INS, 2006).
- Correct placement of the Ommaya reservoir should be confirmed prior to use. Consider the use of a postoperative CT scan or MRI before the administration of intraventricular chemotherapy (Sandberg *et al.*, 2000; Camp Sorrell, 2004).
- Correct placement of the reservoir should be confirmed by slightly depressing the dome several times. There should be free flow of cerebrospinal fluid (CSF) from the ventricle into the dome. If the patient exhibits abnormal neurologic signs the reservoir should not be used (West, 1998; Camp Sorrell, 2004).
- A small non-coring needle or 25-27 gauge scalp vein needle should be used to access the reservoir (West, 1998; Camp Sorrell, 2004; Weinstein, 2007).
- A small amount of CSF equal to the amount of drug/solution to be instilled should be removed prior to the administration of the drug/solution via the Ommaya reservoir. The drug/solution

should be administered slowly. No resistance should be felt during the administration. To facilitate dispersal of the drug/solution within the CSF the dome should be compressed and released. The reservoir can be flushed with the CSF removed at the start of the procedure. Do not flush or heparinise the Ommaya reservoir. This is not required as CSF flows freely through the device (West, 1998).

- The patient should be monitored for complications of use of an Ommaya reservoir such as raised intracranial pressure, headache, confusion, nausea and vomiting, seizures, malposition/migration of the catheter, bleeding, infection, leukoencephalopathy, malfunction, intracerebral haematoma, leakage and skin erosion. Complications should be documented and reported to the doctor (Karavelis *et al.*, 1996; Chamberlain *et al.*, 1998; Sandberg *et al.*, 2000; Camp Sorrell, 2004).
- The nurse caring for the patient should monitor the patient for side-effects of the drugs.
- The patient or caregiver should be taught how to access and maintain the device if appropriate (West, 1998; Kosier and Minkler, 1999; Camp Sorrell, 2004).

8

Infusion therapies

8.1 Medication and solution administration

Standard

The administration of medications and solutions should be in accordance with a prescription from a doctor or an authorised nurse prescriber or as part of a patient group direction (depending on medication or solution) (DH, 2003b; DH, 2004d; NMC, 2006; NPSA, 2007).

Aseptic technique must be used and standard precautions must be observed in the administration of injectable medications and solutions (NPSA, 2007b).

The nurse should where possible check an IV medication with another person prior to administration (NMC, 2007b).

Guidance

- A list of approved medications and solutions for each type of administration (continuous, intermittent or bolus) should be set out in organisational policies and procedures (NPSA, 2007b).
- The nurse should review the prescription for appropriateness for the patient's age and condition, access device, dose, route of administration and rate of infusion/speed of the bolus injection (Taxis and Barber, 2003; NPSA, 2007b).
- The nurse administering medications and solutions should have knowledge of indications for therapy, side-effects and potential adverse reactions, and appropriate interventions (NMC, 2008a; NPSA, 2007b; Finlay, 2008).
- Prior to administration of medications and solutions, the nurse should appropriately label all containers, vials and syringes; identify the patient; and verify contents, dose, rate, route, expiration date, and integrity of the medications or solution (NMC, 2008a; NPSA, 2007b; Finlay, 2008; Hopwood, 2008).

- The nurse should explain and discuss the procedure with the patient prior to administration of medication and gain consent (DH, 2001b; NMC, 2008a; NPSA, 2007b; NMC, 2008b).
- The nurse must be certain of the identification and the allergy status of the patient to whom the medication is to be administered (NMC, 2008a; NPSA, 2007b).
- The nurse should make a clear accurate and immediate record of medications administered, withheld or declined (NMC, 2008a).
- The nurse is accountable for evaluating and monitoring the effectiveness of prescribed therapy; documenting patient response, adverse events, and interventions; and achieving effective delivery of the prescribed therapy (NMC, 2008a).
- The nurse should report any adverse events to the MHRA via the yellow card system and as per organisational policies and procedures.
- After being added to an infusion bag, a medication or solution should be infused or discarded within 24 hours (BMA and RPS, 2008).

8.2 Intrathecal chemotherapy administration

Standard

Intrathecal chemotherapy must be administered in accordance with the updated *National guidance on the safe administration of intrathecal chemotherapy* (DH, 2008; NPSA 2008).

Aseptic technique, standard precautions and protective clothing should be used when preparing and administering intrathecal chemotherapy.

Guidance

- All NHS trusts where intrathecal chemotherapy is administered must ensure full implementation of and adherence to the updated *National guidance on the safe administration of intrathecal chemotherapy* (DH, 2008; DH, 2004e).

- Protocols for the administration of intrathecal chemotherapy should be established in organisational policies, procedures and practice guidelines.
- Aseptic technique should be used when preparing and administering intrathecal chemotherapy.
- Drugs to be administered intrathecally must be prepared using aseptic technique and be free of preservatives (Hyde and Dougherty, 2008b).
- Alcohol should not be used for site preparation, as it is neurotoxic (INS, 2006; West, 1998).
- The patient should be assessed for response to therapy at regular intervals, and findings should be documented in the patient record.
- Complications such as infection, haemorrhage, localised bruising, headache, backache, leakage from the site and arachnoiditis should be documented and reported to the doctor (Hyde and Dougherty, 2008b).
- The nurse caring for the patient should monitor the patient for side-effects of the drugs such as headache, nausea and vomiting, drowsiness, fever, stiff neck and meningitis, although this is rare (Hyde and Dougherty, 2008b).

8.3 Oncology and chemotherapy

Standard

Administration of cytotoxic agents should be initiated upon the prescription of an appropriately qualified clinician (DH, 2000a; DH, 2004a; DH, 2004f).

The patient's informed consent should be obtained prior to the administration of these agents and should be documented in the patient's notes.

The nurse managing cytotoxic agents should be required to have knowledge of, and technical expertise in, both administration and specific interventions associated with cytotoxic agents and have received education and training (RCN, 1998a; DH, 2000a; NHSE, 2001; DH, 2004f).

Guidance

- Protocols for the administration of cytotoxic agents should be set out in organisational policies and procedures.
- The patient and/or caregiver should be informed of all aspects of chemotherapy including the physical and psychological effects, side-effects, risks and benefits (Hyde & Dougherty, 2008).
- Prior to administration of chemotherapeutic agents, laboratory data and other relevant investigations should be reviewed and the patient assessed for appropriateness of the prescribed therapy.
- The nurse administering chemotherapeutic agents should have knowledge of disease processes, drug classifications, pharmacological indications, actions, side-effects, adverse reactions, method of administration (that is, intravenous bolus, intravenous infusion, etc.), rate of delivery, treatment aim (that is, palliative or curative), drug properties (that is, vesicant, non-vesicant or irritant), and specific drug calculations of dose and volume relative to age, height and weight, or body surface area (DH, 2004f).
- Vascular access device types should be selected based on assessment of the prescribed therapy, patient condition and, if appropriate, patient preference.
- Electronic infusion devices should be considered for specific types of chemotherapeutic administration and for all continuous administrations.
- Where possible, a new access site should be initiated prior to any peripheral vesicant administration (Hadaway, 2006).
- Access device patency should be verified prior to the administration of each chemotherapeutic agent by aspirating the device for confirmation of blood return (LSC, 2002; Hadaway, 2006).
- Extravasation protocols should be set out in organisational policies and procedures and implemented when a vesicant extravasates (DH, 2004f).

- When extravasation of a vesicant agent occurs, the extremity should not be used for subsequent vascular access device placement, and alternative interventions should be explored such as discontinuation of therapy, use of the other arm, or use of a central vascular access device.
- Organisational policies and procedures for the protection of personnel and the patient should be in accordance with the COSHH (Control of Substances Hazardous to Health) guidelines. Organisational policies and procedures for the protection of personnel and the patient should be in accordance with the COSHH guidelines (DH, 2004a).
- All chemotherapy should preferably be prepared in a pharmacy setting (COSHH, 2002; NPSA, 2007b).
- The nurse handling and mixing chemotherapeutic agents should strictly adhere to protective protocols, such as mixing under vertical laminar flow hoods or biological safety cabinets and wearing protective clothing.
- Pregnant women or staff planning a pregnancy should be advised of the potential risks associated with handling chemotherapeutic agents and given the opportunity to refrain from preparing or administering these agents.
- Handling of spilled products and equipment used for chemotherapeutic agents should be in keeping with the guidelines for hazardous waste materials (COSHH, 2002; DH, 2004a).

8.4 Patient-controlled analgesia

Standard

Patient-controlled analgesia (PCA) should usually be initiated upon the order of a clinician.

The patient and/or caregiver should be educated in the use of PCA therapy and the patient's and/or caregiver's ability to comply with procedures should be evaluated prior to, and at regular intervals during, therapy.

Medications should be obtained, administered, discarded and documented in accordance with legal requirement for controlled substances.

Guidance

- A protocol for the use of PCA should be established in organisational policies and procedures (Audit Commission, 1997; NPSA, 2007b), together with a protocol for 'step-down' analgesia (NHS QIS, 2004).
- The measurement of pain management outcomes should be defined in the organisational performance improvement programme (Audit Commission, 1997).
- The patient should be involved in the decision-making process (NHS QIS, 2004).
- Patient and/or caregiver information should be clear and understandable, and appropriate to the duration of therapy (short or long-term) and care setting (NHS QIS, 2004). This information should include the purpose of the PCA therapy, operating instructions for the device, expected outcomes, precautions and potential side-effects (Stannard and Booth, 1998; Morton, 1998; RCOA, 2003; NHS QIS, 2004).
- The appropriateness of therapy and patient's comprehension of the intended therapy should be assessed prior to initiation of therapy; whenever possible, patients should be offered the opportunity to self-manage pain by using PCA (Wilkie *et al.*, 1995; Morton, 1998; Smeltzer and Bare, 2000).
- Baseline data should be obtained prior to initiation of therapy and should include patient health status and pain history (Hawthorn and Redmond, 1998; Stannard and Booth, 1998).
- The practitioner must have knowledge of analgesic pharmacokinetics and equianalgesic dosing, contraindications, side-effects, appropriate administration modalities and anticipated outcome, and should document this information in the patient's record (McQuay and Moore, 1998; McQuay, 1999; Portenoy & Lesage, 1999; Taverner, 2003; NPSA, 2007c).

- The practitioner should maintain continued surveillance of the patient and should document assessment and monitoring in the patient's record (Hawthorn and Redmond, 1998).
- Nursing interventions should include evaluating the efficacy of therapy, assessing the need for changing treatment methods, monitoring for potential or actual side-effects and ongoing assessment of patient self-report of pain using a consistent pain scale (Schofield, 1995; Hawthorn and Redmond, 1998; NPSA, 2007c; Stannard and Booth, 1998; Turk and Okifuji, 1999).
- A standard drug solution should be administered via a designated single device in order to reduce the risk of user error (NHS QIS, 2004; NPSA 2007b).
- In order to minimise the risk of adverse outcomes, clearly defined checking procedures reflecting the competency of the practitioner/clinician should be employed prior to administration of analgesia and when the syringe, solution container, or rate is changed, with special attention paid to the concentration of medication and rate of infusion (Brown *et al.*, 1997; Armitage, 2007; NMC, 2008a; NPSA, 2007a; 2007c; 2007e).
- An anti-siphon valve or anti-reflux valve should be used on all extension sets to reduce the risk of the drug solution siphoning into the patient (NHS QIS, 2004).
- The use of PCA infusion devices should adhere to manufacturers' guidelines (Stannard and Booth, 1998).
- The practitioner should be educated and competent in the preparation and use of the electronic infusion device (EID), including programming the device to deliver the prescribed therapy, administration and maintenance procedures, and the use of lock-out safety devices (Stannard and Booth, 1998). All device users should have mandatory device training on a regular basis (NHS QIS, 2004).
- PCA therapy and its outcomes should be documented in the patient's medical and nursing notes (NHS QIS, 2004).

8.5 Parenteral nutrition

Standard

Parenteral nutrition (PN) should be administered according to the order of the clinician.

Informed consent should be obtained prior to commencement of the administration of parenteral nutrition and should be documented in the patient's medical record (Pratt *et al.*, 2007).

Infusion specific filtration and an electronic infusion device should be used during the administration of this therapy.

Administration sets used for PN should be changed every 24 hours and immediately upon suspected contamination or when integrity of the product or system has been compromised.

PN administration sets should be changed using aseptic technique and observing standard precaution.

Guidance

- The nurse should communicate with the clinician, pharmacist and dietician on the development and implementation of the nutrition care plan (King's Fund, 1992; Colagiovanni, 1997; National Collaborating Centre, 2006).
- The nutritional status of the patient should be assessed prior to the commencement of parenteral nutrition and the rationale for its use identified (Weekes *et al.*, 2004).
- Nutritional solutions containing final concentrations exceeding 10% dextrose and/or 5% protein (nitrogen) should be administered via a central venous catheter with tip placement in the superior vena cava (BMA and RPS, 2008).
- Parenteral nutrition solutions in final concentrations of 10% dextrose or lower and/or 5% protein (nitrogen) or lower, should not be administered peripherally for longer than 7-10 days unless concurrent supplementation with oral or enteral feeding is provided to ensure adequate nutrition (BMA and RPS, 2008).
- Parenteral nutrition solutions should be infused or discarded within 24 hours, once the administration set is attached (Shaw, 2008).

- A protocol for changing PN administration sets should be established in organisational policies and procedures (King's Fund, 1992).
- Product integrity should be established before using the administration set.
- The administration set should be replaced every 24 hours. However, when infusing solutions containing only amino acids and glucose, it is not necessary to change the administration set more frequently than every 72 hours, provided that it is in continuous use (Pratt *et al.*, 2007).
- The changing of add-on devices such as, but not limited to, extension sets, filters, stopcocks, and needle-less devices should coincide with the changing of the administration set.
- Parenteral nutrition solutions should be removed from refrigeration one hour prior to infusion in order to reach approximate room temperature.
- Parenteral nutrition solutions not containing lipids should be filtered with a 0.2 micron filter during administration (Weinstein, 2007), or as specified in the product information (BMA and RPS, 2008).
- Parenteral nutrition solutions containing lipid emulsion should be filtered using a 1.2 micron filter during administration, or as specified in the product information (BMA and RPS, 2008).
- Solutions should be prepared in the pharmacy using aseptic technique under a horizontal laminar flow hood (Hart, 2008b).
- Medications added to parenteral nutrition prior to administration of the solution should be assessed for compatibility (BMA and RPS, 2008).
- Medications added to parenteral nutrition should be documented on the label that is affixed to the infusate container (Harkreader, 2000).
- Medications should not be added to the parenteral nutrition solution once it is actively infusing (Weinstein, 2007).
- Parenteral nutrition administration systems, whether central or peripheral, should be dedicated to those solutions (National Collaborating Centre 2006 Pratt *et al.*, 2007; Shaw, 2008).
- A single lumen catheter should be used for the administration of parenteral nutrition. If a multilumen catheter is used, parenteral nutrition should be administered via a lumen kept exclusively for this purpose and strict aseptic technique implemented when handling this lumen (Pratt *et al.*, 2007).
- Push or piggy-back medications should not be added to these infusion systems, with the exception of lipid emulsions with verified compatibility (BMA and RPS, 2008).
- The nurse should monitor the patient for signs and symptoms of metabolic-related complications and electrolyte imbalances (Henry, 1997; Shaw, 2008).
- The nurse should monitor the patient for signs and symptoms of catheter-related complications (Henry, 1997; Sutton *et al* 2005; Pratt *et al.*, 2007).
- The nurse should assess, monitor and document the patient's response to therapy in the patient's medical record (Shaw, 2008).

8.6 Transfusion therapy

Standard

Organisational policies and procedures regarding all aspects of transfusion therapy should be established in accordance with Health Services Circulars 2002/009 *Better Blood Transfusion – appropriate use of blood* (DH, 2002a) and 2007/001 *Better Blood Transfusion – safe and appropriate use of blood* (DH, 2007a), national guidelines and websites for the safe, effective and appropriate use of blood.

Informed consent of the patient or a responsible person legally authorised to act on the patient's behalf must be obtained before administering any transfusion therapy (BCSH, 1999; DH, 2002a; RCN, 2005b; Gray *et al.*, 2007; Bishop, 2008; Hanvey, 2008; NMC, 2008b). A record should be made in the patient's medical notes that the reason for the proposed transfusion has been explained to the patient (or to the responsible person) (McClelland, 2007).

Positive patient identification, appropriateness of therapy and administration setting for blood and/or blood component compatibility must be verified before administering blood and/or blood components (RCN, 2005b). Blood components should only be prescribed by a doctor (BCSH, 1999; McClelland, 2007). Blood components are considered as medicines for administration purposes and should only be administered by a doctor, or a nurse holding current registration with the NMC (BCSH, 1999).

Guidance

- The nurse administering blood or blood components should have an in-depth knowledge and understanding of all aspects of transfusion therapy to ensure safe and effective delivery of care (INS, 2006; Bishop, 2008). This includes immunohaematology, blood and its components, blood grouping, administration equipment and techniques appropriate for each component, transfusion reactions, and the risks to the patient and nurse (INS, 2006).
- All health care practitioners involved in the transfusion process should receive appropriate education (RCN, 2005b) and be competency assessed (NPSA, 2006).
- Blood components must be transfused through a blood administration set with an integral mesh filter (170-200 micron pore size) (RCN, 2005b). Standard blood administration sets contain in-line filters that will remove particles of 170-200 microns and above (BCSH, 1999; McClelland, 2007).
- The use of additional in-line blood filters is not indicated for the majority of transfusions. For infants and small children a standard giving set with a screen filter (170-200 microns) or an alternative system incorporating the same filtration must be used. Where small volumes are drawn into a syringe an appropriate filter must be used (BCSH, 2004).
- All blood components are leukocyte-depleted within 48 hours of collection in the UK to minimise the theoretical risk of transmission of new variant Creutzfeldt-Jakob disease. Leukocyte depletion filters are no longer used and may be detrimental (McClelland, 2007; Hanvey, 2008).
- For information on the use of blood warmers see Standard 4.5.
- Temperature, pulse and blood pressure should be measured and recorded before the start of each unit of blood/blood component, and when the unit is completed. Temperature and pulse should be measured 15 minutes after the start of each unit of blood/blood component. The patient should be observed throughout the transfusion. Further observations need only be taken if the patient becomes unwell or shows signs of a transfusion reaction (conscious patient). If the patient is unconscious, their pulse and temperature should be checked at intervals during the transfusion. Transfusions should only be administered in clinical areas where patients can be readily observed by clinical staff (BCSH, 1999; RCN, 2000b; Gray *et al.*, 2007; McClelland, 2007).
- Document the start and finish times of each unit of blood. Record the volume of blood transfused on the patient's fluid balance chart or 24 hour chart (Hanvey 2008). Document the fate of the blood or blood component and if it was returned to the laboratory untransfused (DH, 2005c; 2005d).
- There is no minimum or maximum size of cannula for administration of blood/blood components. The cannula size used should depend on the size of the vein and the speed at which the transfusion is to be infused (BCSH, 1999; Acquillo, 2007; McClelland, 2007).
- All red cell units should be transfused within four hours of removal from the blood fridge or hospital transfusion laboratory (RCN, 2005b).
- Fresh frozen plasma and platelets should be transfused immediately they are received in the clinical area.
- For the administration of transfusion therapy outside a hospital setting the Haematology guidelines for out-of-hospital blood transfusion should be followed (BCSH, 1999).
- Conventional guidance is that drugs should not be added to any blood component pack. Dextrose solution (5%) can cause haemolysis and must not be mixed with blood components. Calcium solutions may cause a clotting of citrated blood.

Desferrioxamine may be administered via a Y connection with blood (RCN, 2005b).

- Transfusion reactions require immediate nursing and/or medical intervention. If a transfusion reaction is suspected stop the transfusion and immediately inform the doctor. If the reaction appears life-threatening, call the resuscitation team. Record the adverse event in the patient record. Report the adverse event in accordance with local hospital policy and national reporting procedures (RCN, 2005b; UK Blood Safety & Quality Regulations, 2005). The blood and the administration set should be retained for analysis by the blood transfusion laboratory.
- Hospitals should have a policy for the management and reporting of adverse events (including 'near misses') following transfusion of blood components. All adverse events related to transfusion reactions should be reported to the hospital transfusion department. In addition, all transfusion reactions should be reviewed by the Hospital Transfusion Committee. Serious non-infectious adverse events and near miss events should be reported to the Serious Hazards of Transfusion (SHOT, 2004) reporting scheme and the MHRA. Adverse events associated with licensed plasma derivatives or blood products should be reported to the UK Medicines Control Agency (BCSH, 1999; McClelland, 2007).
- External compression devices should be equipped with a pressure gauge and must exert uniform pressure against all parts of the blood container (INS, 2006).
- Electronic infusion pumps may be used for blood components providing they have been verified as safe to use for this purpose according to the manufacturer's instructions (BCSH, 1999; RCN, 2005b; McClelland, 2007).
- Blood and blood components should be transfused using a sterile administration set designed for this procedure. For platelet concentrates a standard blood or platelet administration set should be used. Platelets must not be transfused through administration sets that have been used for red cells. Special paediatric administration sets should be used for transfusion to an infant, or a screen filter used if the transfusion is to be administered via syringe

(BCSH, 1999; McClelland, 2007). Change the administration set at least every 12 hours for a continuing transfusion and on completion of the transfusion (RCN, 2005b).

- All trusts involved in blood transfusion are required to ensure that *Better Blood Transfusion* is an integral part of NHS care, to make blood transfusion safer as part of clinical governance responsibilities, avoid unnecessary use of blood and provide better information to patients and the public about blood transfusion (DH, 2002a).
- Patient information is essential to ensure informed consent (Bishop, 2008). Information sheets that outline the risks and benefits of blood transfusion can be helpful to patients. The NHS leaflet *Will I need a blood transfusion?* (available from hospital blood banks) and The National Blood Service Hospitals and Science Website <http://hospital.blood.co.uk> or locally produced information can be used (McClelland, 2007). Examples of patient information leaflets will (in the future) be available from the Better Blood Transfusion website www.betterblood.org.uk.

Websites

Guidelines for the Blood Transfusion Services in the United Kingdom: <http://www.transfusionguidelines.org.uk>

British Blood Transfusion Society: www.bbts.org.uk

British Committee for Standards in Haematology guidelines: www.bcshguidelines.com

Better Blood Continuing Education Programme, E-learning website: www.learnbloodtransfusion.org.uk

NHS leaflet *Will I need a blood transfusion?:* http://hospital.blood.co.uk/library/pdf/INF_PCS_HL_001_05_will_i_need_leaflet_ENGLISH.pdf

8.7 Intravenous conscious sedation

Standard

Intravenous conscious sedation (IVCS) should be initiated upon the order of a clinician or in accordance with individual organisations' policies and procedures (e.g. patient group directions) and should

be provided in a controlled setting, with appropriate monitoring and resuscitation equipment available.

Informed consent (including the risks of IVCS) should be obtained from the patient, or a representative legally authorised to act on the patient's behalf, prior to the procedure and documented in the patient's medical and nursing notes.

Guidance

- Patients should be assessed for any health problems and any risks associated with having their procedure under IVCS (DH, 2003a; RCR, 2003; NCEPOD, 2004a; NGC, 2004; SIGN, 2004; Reschreiter and Kapila, 2006; Sury, 2006; DH, 2007b).
- Prior to IVCS, patients should be advised that they may experience a prolonged period of impaired cognition following their procedure and therefore should not make any legally binding or lifestyle changing decisions (RCR, 2003; Marriot *et al.*, 2004; NGC, 2004).
- Patients receiving IVCS in an ambulatory health care facility should have a responsible adult to accompany them home, via car or taxi, and remain with them for 12-24 hours after the procedure (DH, 2003a). Post-procedural information/instructions for the patient should be reinforced in written form, in recognition of the patient's possible impaired cognition. This information should include signs and symptoms of possible adverse outcomes and complications (DH, 2003a; RCR, 2003; Marriot *et al.*, 2004; NGC, 2004; DH, 2007b).
- A clinician should select and order the medications for conscious sedation (Smeltzer and Bare, 2000; RCOA, 2001; RCR, 2003).
- In order to minimise the risk of adverse outcomes, clearly defined checking procedures reflecting the competency of the practitioner/clinician should be employed prior to administration of analgesia and when the syringe, solution container, or rate is changed, with special attention paid to the concentration of medication and rate of infusion (Armitage, 2007; NMC, 2008a; NPSA, 2007a; NPSA, 2007e).
- Guidelines for drug administration, patient monitoring and response to complications and emergencies should be available and established in accordance with evidence-based practice (Berlin, 2001; DH, 2002b; SIGN, 2004).
- The practitioner should demonstrate knowledge of the risks of airway obstruction, its management and the identification of 'at risk' patients (Miller *et al.*, 1997; Benumof, 2001; DH, 2002b; DH, 2004b; SIGN, 2004; Reschreiter and Kapila, 2006; DH, 2007b; Bellamy and Struys, 2007).
- The practitioner managing the patient receiving IVCS should be educated and competent in the principles of IVCS and the administration of the therapy. The organisation providing the service should have an education and competency verification system in place (Greenfield *et al.*, 1997; Sury *et al.*, 1999; Laurence, 2000; Smeltzer and Bare, 2000; RCOA, 2001; DH, 2003a; Marriot *et al.*, 2004; SIGN, 2004; NAO, 2005).
- IVCS should be performed in a controlled setting, which includes a clinician, available written protocol and appropriate equipment for administering the therapy, monitoring the patient and for resuscitation (Laurence, 2000; RCOA, 2001; DH, 2002b; BSG, 2003; DH, 2003a; NCEPOD, 2004b; NGC, 2004; Reschreiter and Kapila, 2006).
- The safety of IVCS will be optimised by practitioners using clearly defined techniques of sedation, for which the clinician/practitioner has been trained (RCOA, 2001; RCR, 2003; DH, 2007b).
- Safety of the patient is increased when a single sedative drug is used. Combinations of drugs or a 'cocktail', while sometimes necessary, reduce the margin of safety between 'conscious sedation' and 'anaesthesia' due to the synergistic effect of the drugs and is associated with an increased risk of cardio-respiratory problems (Coté *et al.*, 2000; RCOA, 2001; DH, 2002b; SIGN, 2004; DH, 2007b). The appropriate reversal agents should be available (RCOA, 2001; Sury, 2006).

- The patient receiving IVCS should be continuously monitored and vascular access should be maintained throughout the procedure (Booth, 1996; Smeltzer and Bare, 2000; DH, 2004b; NCEPOD, 2004b; SIGN, 2004; Sury, 2006; DH, 2007b). The practitioner must have received formal training in monitoring and resuscitation, and should have knowledge of the sedation rating scales which can be used to assess the patient (Miller *et al.*, 1997; NCEPOD, 2004b; Reschreiter and Kapila, 2006; DH, 2007b).
- The practitioner managing the patient receiving IVCS should not leave the patient unattended or compromise continuous monitoring by participating in other duties (Smeltzer and Bare, 2000; DH, 2002b; NCEPOD, 2004b; SIGN, 2004; Reschreiter and Kapila, 2006).
- Paediatric patients should be managed by a clinician/practitioner with the requisite specialist skills (SIGN, 2004).
- Standard monitoring includes: level of responsiveness, heart rate, blood pressure, respiratory rate and oxygen saturation (DH, 2003a; RCR, 2003; DH, 2007b; NGC, 2004). Factors that should be taken into account when deciding on ECG monitoring include: cardiovascular disease, American Society of Anesthesiologists (ASA) status and the potential for cardiovascular instability (for example during upper GI endoscopy). Continuous ECG monitoring is indicated in patients with significant arrhythmia or cardiac dysfunction, older patients and when a prolonged procedure is anticipated (NGC, 2004). Capnography may also be indicated for prolonged procedures (RCR, 2003; NGC, 2004; SIGN, 2004; Sury, 2006). Supplemental oxygen should be administered during all endoscopies (BSG, 2003) to reduce the incidence of hypoxaemia (RCR, 2003). A contemporaneous monitoring record should be maintained: the frequency of recordings will be dependent on the patient's physical status (RCR, 2003; NCEPOD, 2004b).
- After IVCS the patient should continue to be monitored for a period dependent on the assessed risk to the patient, in a dedicated recovery facility with appropriate equipment and suitably trained staff, regardless of the timing of the procedure (RCR, 2003; NGC, 2004; SIGN, 2004; DH, 2007b).

8.8 Epidural analgesia infusion

Standard

The epidural analgesia infusion should be initiated upon the order of a clinician.

The patient and/or caregiver should be educated and competent in the use of epidural infusion and the patient's and/or caregiver's ability to comply with procedures should be evaluated prior to, and at regular intervals during, therapy.

Medications should be obtained, administered, discarded and documented in accordance with legal requirements for controlled substances.

Special precautions should be taken in order to minimise the risk of epidural medication being incorrectly administered.

Guidance

- A protocol for the use of epidural analgesia should be established in organisational policies and procedures (Audit Commission, 1997; Morton, 1998), together with a protocol for 'step-down' analgesia (NHS QIS, 2004). Guidelines on the management of potential problems and adverse outcomes should also be available (NHS QIS, 2004).
- Continuous epidural analgesia should only be used in environments where this method of analgesia is frequently employed, in order to optimise expertise and safety (RCOA, 2004). There must be 24-hour access to advice from an anaesthetist (RCOA, 2004).
- The measurement of pain management outcomes should be defined in the organisational performance improvement programme (Audit Commission, 1997; Morton, 1998).
- The patient should be involved in the decision-making process (NHS QIS, 2004).
- Patient and/or caregiver information should be appropriate to the duration of therapy (short or long-term) and care setting. This information should include the purpose of the therapy, operating instructions for the device, expected outcomes, precautions and potential side-effects (Morton, 1998; Stannard and Booth, 1998; RCOA, 2004).

- The appropriateness of epidural analgesia, the environment and patient's comprehension of the intended therapy should be assessed prior to initiation of therapy; whenever possible, patients should be offered the opportunity to self-manage pain by using patient-controlled epidural analgesia (PCEA) (Wilkie *et al.*, 1995; Morton, 1998; Smeltzer and Bare, 2000).
- Baseline data should be obtained prior to initiation of therapy and should include patient health status and pain history (Hawthorn and Redmond, 1998; Stannard and Booth, 1998; Wigfull and Welchew, 2001).
- The patient must have a patent venous access device *in situ* during epidural analgesia (NHS QIS, 2004).
- The practitioner must have knowledge of analgesic pharmacokinetics and equianalgesic dosing, contraindications, side-effects, appropriate administration modalities and anticipated outcome, and should document this information in the patient's medical and nursing notes (McQuay and Moore, 1998; Stannard and Booth, 1998; McQuay, 1999; Wigfull and Welchew, 1999; Wigfull and Welchew, 2001; Taverner, 2003).
- The practitioner should maintain continued surveillance of the patient and should document assessment and monitoring in the patient's record (Hawthorn and Redmond, 1998; Morton, 1998; Stannard and Booth, 1998).
- Nursing interventions should include evaluating the efficacy of therapy, assessing the need for changing treatment methods, monitoring for potential or actual side-effects and ongoing assessment of patient self-report of pain using a consistent pain scale (Schofield, 1995; Hawthorn and Redmond, 1998; Stannard and Booth, 1998; Turk and Okifuji, 1999; Wigfull and Welchew, 2001).
- Aseptic technique should be observed during the insertion of the epidural catheter (RCOA, 2004).
- The patient should be monitored for infective complications and the presence of neurological sequelae.
- Epidural analgesia catheters should be colour-coded and easily identifiable (NPSA, 2007d); they should not include injection ports (NHS QIS, 2004); and an antibacterial filter should always be used (RCOA, 2004). The catheter should be secured so that movement of the catheter in and out of the epidural space is minimised and the dressing should facilitate inspection of the insertion site (RCOA, 2004).
- There should be protocols or guidelines that identify a restricted list of drugs and their concentrations, which can be used for epidural infusion (RCOA, 2004; NPSA, 2007d). Clear labels should permit the practitioner to easily distinguish epidural infusions from other infusions (RCOA, 2004; NPSA, 2007d). Specific storage for epidural solutions should be provided to separate them from other infusions (RCOA, 2004; NPSA, 2007d).
- A standard drug solution should be administered via a designated single device in order to reduce the risk of user error (NHS QIS, 2004; NPSA, 2007d).
- In order to minimise the risk of adverse outcomes, clearly defined checking procedures reflecting the competency of the practitioner/clinician should be employed prior to administration of analgesia and when the syringe, solution container, or rate is changed, with special attention paid to the concentration of medication and rate of infusion (Brown *et al.*, 1997; Armitage, 2007; NPSA, 2007a; 2007d; 2007e; NMC, 2008a).
- The use of epidural infusion devices should adhere to manufacturers' guidelines (Stannard and Booth, 1998).
- Epidural pumps should be clearly identified (NPSA, 2007d) and specifically set up for continuous epidural infusion with pre-set limits for maximum infusion rate and bolus size (RCOA, 2004). The practitioner should be educated and competent in the preparation and use of the electronic infusion device including programming the device to deliver the prescribed therapy, administration and maintenance procedures, and the use of lock-out safety devices (Stannard and Booth, 1998; Wigfull and Welchew, 1999; 2001; NPSA, 2007d). All device users should have mandatory device training on a regular basis (NHS QIS, 2004).

- Patients having epidural analgesia should have deep vein thrombosis (DVT) prophylaxis adjusted, as appropriate, to minimise the risk of epidural haematoma (NHS QIS, 2004).
- Patients who have had orthopaedic or vascular surgery should be observed in order to detect the development of compartment syndromes (RCOA, 2004).
- Epidural analgesia therapy, together with any complications, should be documented in the patient's record (Cooper, 1996; Stannard and Booth, 1998; Hutton and Christie, 2001; Malak *et al.*, 2001; NPSA, 2007b; 2007c) together with observations of the patency of the VAD and integrity of pressure areas.
- Prior to commencing IVIG, informed, written consent must be obtained from the patient (NMC, 2008b) or person with parental responsibility if the patient is a child (DH, 2002c). This should include the risk of infection (viral infections and theoretical risk of transmission of vCJD), the process of infusion and adverse reactions that may occur. The consent process should be documented in the medical record (UKPIN, 2004; UKPIN, 2005; Shelton *et al.*, 2006; TRIAC, 2007).
- The patient must have an infusion partner/carer who agrees to be trained to administer the IVIG infusion (UKPIN, 2005; TRIAC, 2007).
- If IVIG is administered in the home setting by a community nurse, patient, parent or caregiver, the person administering the IVIG should be able to recognise the side-effects and signs of an allergic/anaphylactic reaction and take the appropriate action(s). A pre-filled syringe containing adrenaline (for example Epi-pen™) should be readily available for use and the caregiver taught to seek medical help/call an ambulance should an allergic/anaphylactic reaction occur (Royal College of Pathologists *et al.*, 1995; Nolet, 2000; RCN, 2001; TRIAC, 2007; Kayley, 2008).
- If IVIG is to be administered in the home setting the caregiver/patient/parent should be educated in the preparation and administration of IVIG, hand-washing, aseptic technique, use of any delivery system, venepuncture, blood sampling, correct infusion rates, disposal of used equipment, immediate and long-term side-effects, potential adverse reactions, and instructed in the use of pre-filled adrenaline syringes (Nolet, 2000; RCN, 2001; UKPIN, 2005; TRIAC, 2007).
- Patients and carers trained to administer IVIG in the home should be formally trained by a specialist immunology nurse (RCN, 2001). The specialist nurse must be competent in the administration of intravenous medication, possess a teaching and assessing certificate or equivalent, and have experience of home intravenous therapy training (UKPIN, 2005).
- The agreement of the GP and/or primary care trust should be obtained and mechanisms for funding established before instigating a home

8.9 Intravenous immunoglobulin therapy

Standard

Intravenous immunoglobulin (IVIG) should be prepared and administered using aseptic technique and sterile or non sterile gloves (NPSA, 2007; TRIAC, 2007). Aseptic technique with sterile gloves may be used for administration of intravenous medications via a central venous access device (Pratt *et al.*, 2007).

The nurse administering intravenous immunoglobulin should be knowledgeable about the indications for IVIG therapy, normal dosage, side-effects, precautions and contraindications, potential adverse reactions and the appropriate interventions (NMC, 2008a; NPSA, 2007f; Finlay, 2008).

Measures should be taken to minimise the risk of allergic/anaphylactic reactions during the administration of IVIG (Shelton *et al.*, 2006).

IVIG should be administered in a safe, appropriate environment (United Kingdom Primary Immunodeficiency Network (UKPIN), 2005; Trent Immunology and Allergy Consortium (TRIAC), 2007).

Guidance

- Protocols for the administration of IVIG should be set out in organisational policies and procedures.

training programme. In addition, a system for prescribing the IVIG should be in place and arrangements made for the supply of the IVIG/ other equipment by a community pharmacy service or hospital pharmacy (UKPIN, 2005).

- Before starting home administration of IVIG the patient should have experienced no adverse reactions/events for 4-6 months (UKPIN, 2005; TRIAC, 2007).
- Patients receiving IVIG in the home setting must have telephone access, in order to call the emergency services (UKPIN, 2005; TRIAC, 2007).
- Patients receiving IVIG in the home setting must agree to continued monitoring and review as determined by the specialist hospital (UKPIN, 2005; TRIAC, 2007). Monitoring includes blood samples for liver function, trough IgG levels and CRP. Additional samples may be required at least yearly for functional antibodies (selected patients), full blood count with haematinics as required, anti-IgA antibodies, hepatitis BsAg and hepatitis C PCR and store serum (TRIAC, 2007).
- The competence of the patient/infusion partner should be assessed yearly (UKPIN, 2005; TRIAC, 2007).
- The use of permanent venous access devices should be avoided where possible as the patient has an increased susceptibility to infection (RCN, 2001). However, when necessary, the patient receiving long-term IVIG therapy should be considered for placement of an appropriate venous access device (Nolet, 2000; Schleis, 2000; Bravery, 2008; Kayley, 2008). Good venous access is essential for home IVIG administration (UKPIN, 2005; TRIAC, 2007).
- IVIG should be prepared, stored and administered according to the manufacturer's guidelines (TRIAC, 2007). Once prepared the infusion should be labelled (NPSA, 2007f; NPSA, 2007b). Once the IVIG has been reconstituted it should be administered promptly as it contains no preservatives (check manufacturers' instructions) (Nolet, 2000; Schleis, 2000; Weinstein, 2007).
- The IVIG infusion should be started slowly and the rate increased in incremental steps until the patient's maximum infusion rate is reached. Once tolerance has been established, the infusion can be administered more rapidly. This procedure should be followed each time the brand of IVIG is changed (Schleis, 2000). Side-effects and adverse reactions are reduced by avoidance of rapid infusion rates (Cornelius, 2000; Swenson, 2000).
- Infusion rates are calculated at ml/kg/minute. It is important that an accurate weight is used to calculate the infusion rate (Nolet, 2000; Shelton *et al.*, 2006).
- The administration set used to administer IVIG may require a 15-micron filter to prevent infusion of undissolved immunoglobulin or other foreign material into the patient. Check manufacturers' instructions as not all products require a filter (Shelton *et al.*, 2006).
- The patient should be observed during infusion of IVIG for signs of an adverse reaction. Baseline observations of pulse, blood pressure and temperature should be recorded. These should only be repeated as indicated (TRIAC, 2007). Observations every 5-15 minutes will be necessary if the patient experiences a reaction (Shelton *et al.*, 2006).
- Common side-effects such as headache and slight hypotension may be alleviated by slowing the infusion rate (Schleis, 2000).
- Flu-like symptoms can be treated with the administration of either paracetamol or ibuprofen pre- and post-infusion (Schleis, 2000; Swenson, 2000).
- Post-infusion headaches accompanied by nausea and vomiting (aseptic meningitis) can occur from 12 hours to several days after the IVIG. This may be treated by administration of antihistamines, corticosteroids and hydration before the infusion and analgesia post-infusion as necessary. These symptoms may be relieved by administering IVIG as a 24-hour infusion (Schleis, 2000; Swenson, 2000; Shelton *et al.*, 2006). Using an alternative IVIG product may prevent recurrence of the headache (Shelton *et al.*, 2006).
- Anaphylaxis/allergic reactions are rare and are associated with the first infusion of IVIG or when products are changed. If a reaction occurs antihistamines, corticosteroids and adrenaline may be required. An emergency trolley and

oxygen should be readily available during first infusion or brand change of IVIG. This type of reaction diminishes with subsequent infusions. Pre-medication with antihistamine and corticosteroid lessens the risk of a reaction (Nolet, 2000; Schleis, 2000; Shelton *et al.*, 2006).

- If an adverse event occurs the necessary action should be instigated, the event should be reported to the prescriber/patient's consultant and documented in the patient record (NMC, 2008a).
- First and second doses of IVIG should be administered in a hospital setting (Cornelius, 2000). Where the brand is changed, the first and second doses of the new brand should also be administered in a hospital setting.
- If a patient has an active infection present the IVIG should be delayed for a few days until the infection has been treated with antibiotics. An adverse reaction is more likely to occur if an infection is present (TRIAC, 2007).
- Methods should be employed to minimise the risk of pathogen transmission via IVIG (Lee *et al.*, 2000; Swenson, 2000). IVIG products available in the UK are manufactured in an MHRA-approved facility. All licensed products must be manufactured under the terms of an approved manufacturer's license. The minimum requirements for manufacture are defined in the *Good Manufacturing Practice (GMP) Commission Directive 2003/94/EC* (National Blood Service, 2005).
- If the patient is deficient in immunoglobulin A (IgA) and has high titre anti-IgA antibodies the patient should receive IgA-depleted immunoglobulin (Shelton *et al.*, 2006).
- The batch number should be recorded to facilitate rapid identification of contaminated batches (TRIAC, 2007).

Websites

Primary Immunodeficiency Association:
www.pia.org.uk

UK Primary Immunodeficiency Network (UKPIN):
www.ukpin.org.uk

8.10 Apheresis procedures (donor/therapeutic)

Standard

Apheresis procedures should be undertaken by a trained practitioner with the experience, knowledge and skills to perform this procedure (BCSH, 1998; National Blood Service (NBS), 2005; Foundation for the Accreditation of Cellular Therapy, Joint Accreditation Committee ISCT-EBMT (FACT-JACIE), 2007).

Aseptic technique, ANTT, protective clothing, gloves and standard precautions should be observed during apheresis procedures where appropriate (NBS, 2005; FACT-JACIE, 2007).

Apheresis procedures should be performed in accordance with the NMC's *Code* (NMC, 2008b) or other profession-specific regulations.

Apheresis procedures performed on healthy donors should comply with the *Guidelines for the blood transfusion services in the United Kingdom* (NBS, 2005).

The collection, processing and administration of haematopoietic progenitor cells obtained by apheresis should comply with the *FACT-JACIE International standards for cellular therapy product collection, processing and administration* (FACT-JACIE, 2007) and *Directive 2004/23/EC* (NBS, 2005).

The use of cell separators for therapeutic apheresis procedures should comply with the *BCSH Guidelines for the clinical use of blood cell separators* (BCSH, 1998).

Guidance

- Protocols for apheresis procedures should be set out in organisational policies, procedures and practice guidelines.
- The venous access device used for apheresis procedures must be able to withstand the high flow rates necessary for apheresis (Haire and Sniecinski, 1994; Secola, 1997; Rhodes and Sorensen, 2004; Bishop *et al.*, 2007).
- Peripheral or central venous access may be used (BCSH, 1998; NBS, 2005).

- Clinical decisions regarding the use of blood cell separators are the responsibility of a medical consultant (or equivalent) (BCSH, 1998).
- Informed consent for apheresis procedures should be obtained from the patient (or person with parental responsibility if the patient is a child) and the donor (or person with parental responsibility if the donor is a child) (BCSH, 1998; DH, 2002c; NBS, 2005; FACT-JACIE, 2007). Informed consent must be obtained by a doctor or registered nurse, fully conversant with the procedure (NBS, 2005). Informed consent should include discussion of the risks of the procedure, central venous access and anaesthesia required (FACT-JACIE, 2007).
- The selection of patients and donors and their pre-donation medical and laboratory assessment is the responsibility of a medical officer who is familiar with the use of cell separators. Volunteer donors (related and unrelated) must fulfil the appropriate UK guidelines for selection of donors. Donors should not be subjected to undue pressure to donate (BCSH, 1998; NBS, 2005).
- Paediatric patients require special care and should only be selected and managed by staff trained in the clinical assessment and management of children (BCSH, 1998; Bravery and Wright, 1998). Age-specific issues must be addressed. More specifically these include the age and size of the donor, informed consent/assent, and the need for central venous access (FACT-JACIE, 2007).
- Practitioners responsible for donor/patient care during apheresis should be trained according to the specific requirements for training in the *Guidelines for the blood transfusion services in the United Kingdom* (NBS, 2005) and the FACT-JACIE Standards (FACT-JACIE, 2007). Practitioners should have knowledge of the potential complications of apheresis and the management of these complications (BCSH, 1998).
- Blood components must be collected by apheresis using sterile, single use, disposable items that are licensed by the MHRA and is compliant with the CE marketing directive (NBS, 2005; FACT-JACIE, 2007). A record should be kept of all lot and/or batch numbers of all apheresis set components used (NBS, 2005).
- Blood cell separators should be used, serviced and operated in accordance with the manufacturer's instructions (BCSH, 1998; NBS, 2005; FACT-JACIE, 2007).
- Staff proficiency in the operation of cell separators must be maintained by regular use of the equipment (BCSH, 1998).
- Practitioners undertaking apheresis procedures should be trained in cardiopulmonary resuscitation (BCSH, 1998; NBS, 2005).

8.11 Blood sampling

Standard

Blood sampling (venepuncture, blood cultures, capillary blood sampling or via vascular access devices) should be performed on request of a clinician and/or health care professional or according to established protocols, using aseptic technique and observing standard precautions.

All hazardous materials and waste must be discarded in the appropriate containers and disposed of safely according to statutory requirements (see 2.7).

Guidance

- The patient should be positively identified before obtaining a blood sample (RCN, 2005b; NPSA, 2007; Hanvey, 2008).
- Blood collection tubes should not be pre-labelled (Hanvey, 2008).
- Blood collection tubes should be checked for expiration date.
- Samples should be taken in the sampling order recommended by the manufacturer (Lavery and Ingram, 2005).
- The amount of blood obtained for discard should be sufficient to avoid laboratory error without compromising the patient.
- For the paediatric patient, the amount of blood obtained for laboratory assay should be documented in the patient's nursing notes.

- Blood collection tubes should be clearly labelled with patient identifiers only once the blood samples have been obtained (Hanvey, 2008; Witt, 2008).
- Blood samples should be transported in an accepted biohazard container.
- Where appropriate samples should be identified with a biohazard label prior to sending them to the laboratory.
- Safety blood collection devices which reduce the risk of accidental needlestick injury should be used (NHS Employers, 2007; Dougherty, 2008a; Witt 2008).
- Proper haemostasis should be maintained at the venepuncture site after removal of the needle, and instructions should be given to the patient to report any bleeding (Lavery and Ingram, 2005).

Blood sampling via access devices

- Peripheral cannulae should not be used routinely for blood sampling in adults but may be used to take samples at initial placement of device. However, if necessary then using a large syringe (larger than 10 ml) or a vacuum system to obtain blood samples from a cannula may increase haemolysis of the sample. Consideration should be given to the use of a smaller syringe to obtain samples (Seeman and Reinhardt, 2000).
 - Blood should not be drawn through an infusion administration set.
 - If the patient has an infusion in progress, the infusion should be stopped and the device flushed prior to blood sampling.
 - Venous access devices should be flushed with a sufficient volume of 0.9 per cent sodium chloride solution (injectable) to clear the catheter of all residual blood after blood sampling.
 - The most appropriate method for obtaining blood samples from venous access devices is not yet established by research (Keller, 1994). Three methods are reported in the literature – the push-pull or mixing method, the discard method and the reinfusion method (Hinds *et al.*, 1991; Cosca *et al.*, 1998; Holmes, 1998; Frey, 2003; Hinds *et al.* 2002).
 - Blood samples, for example coagulation tests and drug levels, obtained from access devices may be inaccurate (Pinto, 1994; Mayo *et al.*, 1996).
 - Samples obtained from an arterial access device should be labelled as ‘arterial blood’ to ensure correct reference ranges are used when interpreting blood results (Dougherty and Watson, 2008).
- #### **Blood sampling via direct venepuncture**
- The venepuncture site should be cleaned according to organisational policies and procedures. If blood cultures are to be taken then the skin must be cleaned with 2% chlorhexidine (DH, 2007e).
 - Patient education, assessment and monitoring should be ongoing during the phlebotomy procedure.
 - The practitioner performing venepuncture should minimise discomfort to the patient and utilise measures to reduce the fear, pain and anxiety associated with venepuncture (Lavery and Ingram, 2005; Dougherty, 2008a).
 - The practitioner performing venepuncture should be knowledgeable about the relevant anatomy and physiology, skin preparation and asepsis, measures to improve venous access, and be aware of the contraindications of venepuncture sites (Dougherty, 2008a; Witt, 2008; Scales 2008b).
 - The smallest possible gauge needle should be used (Black and Hughes, 1997; Weinstein, 2007).
 - Gloves should be available to all practitioners and worn during the venepuncture procedure (IPS, 2003) (see 2.3).
 - Blood samples should be obtained from the non-cannulated extremity; when this is not possible, the peripheral infusion should be stopped and flushed to prevent device occlusion and the venepuncture made distal to the cannula location (Dougherty, 2008a).

9

Infusion-related complications

9.1 Phlebitis

Standard

Phlebitis is the inflammation of the tunica intima of the vein. There are three types of phlebitis: mechanical, chemical and infective (Macklin, 2003).

Statistics on incidence, degree, cause and corrective action taken for phlebitis should be maintained and readily retrievable (Bravery *et al.*, 2006; Grune *et al.*, 2004).

The nurse must be competent to assess the access site and determine the need for treatment and/or intervention in the event of phlebitis.

Phlebitis should be documented using a uniform standard scale for measuring degrees or severity of phlebitis (Jackson, 1998; Gallant and Schultz, 2006).

Guidance

- The phlebitis scale should be standardised and used in documenting phlebitis and may require adaptation depending on the device used, e.g. midline/PICC. Phlebitis should be graded according to the most severe presenting indicator (Jackson, 1998; Gallant and Schultz, 2006) (see Appendix 1).
- Each organisation should have guidelines regarding prevention and management of phlebitis. These should include appropriate device and vein selection, dilution of drugs and pharmacological methods, for example glycerol trinitrate (GTN) patches (Jackson, 1998).
- All vascular access sites should be routinely assessed for signs and symptoms of phlebitis (DH, 2003c).
- The nurse should have knowledge of the management of phlebitis (Lamb and Dougherty, 2008).

- Any incident of phlebitis rating Grade 1 or higher should be investigated by the appropriate health care professional to identify the cause and possible steps for future prevention.
- Any incident of phlebitis, along with intervention, treatment and corrective action, should be documented in the patient's nursing notes.
- Organisational policies and procedures should require calculation of phlebitis rates as a means of outcome assessment and performance improvement (INS, 2006).
- The peripheral phlebitis incidence rate should be calculated according to a standard formula (INS 2006):

$$\frac{\text{Number of phlebitis incidents}}{\text{Total number of IV peripheral devices}} \times 100 = \text{\% peripheral phlebitis}$$

9.2 Infiltration

Standard

Infiltration should be defined as the inadvertent administration of non-vesicant medication or solution into the surrounding tissue instead of into the intended vascular pathway (Fabian, 2000; INS, 2000; Hadaway, 2002; Lamb and Dougherty, 2008).

An infiltration should be identified and assessed by the nurse, and appropriate nursing intervention should be implemented to minimise the effects of the infiltration (Hadaway, 2002; INS, 2006).

All information related to the event, including photographic records where appropriate, should be reported and documented in the patient's medical and nursing notes (Hadaway, 2002).

Guidance

- The infiltration scale should be standardised and used in documenting the infiltration; infiltration should be graded according to the most severe presenting indicator (INS, 2006; see Appendix 2).
- Observation of an infiltration occurrence should prompt immediate discontinuation of the infusion (Dougherty, 2008b).

- Treatment should be dependent upon the severity of the infiltration (Dougherty, 2008b).
- Ongoing observation and assessment of the infiltrated site should be performed and documented (Hadaway, 2002).
- The presence and severity of the infiltration should be documented in the patient's medical and nursing notes (Hadaway, 2002).
- Infiltration statistics should be maintained and should include frequency, severity and type of infusate.
- The infiltration rate should be calculated according to a standard formula:

$$\frac{\text{Number of infiltration incidents}}{\text{Total number of IV peripheral devices}} \times 100 = \text{\% peripheral phlebitis}$$

9.3 Extravasation

Standard

Extravasation should be defined as the inadvertent administration of vesicant medication or solution into the surrounding tissue instead of into the intended vascular pathway (RCN, 1998; Perucca, 2009; Stanley, 2002; Polovich *et al.*, 2009; INS, 2006).

All organisations must have a policy relating to the recognition, prevention, management and reporting of extravasation (Polovich *et al.*, 2009; EONS, 2007; Hyde and Dougherty, 2008b).

An extravasation should be identified and assessed by the nurse, and appropriate nursing interventions should be implemented to minimise the effects of the extravasation (Hyde and Dougherty, 2008; Schulmeister, 2009).

Extravasation should prompt immediate discontinuation of the infusion and should require immediate intervention (Stanley, 2002; Goodman, 2005; EONS, 2007; Weinstein, 2007; Hyde and Dougherty, 2008).

All information related to the event should be documented in the patient's medical and nursing notes and on a clinical incident form (INS, 2006; EONS, 2007; Dougherty, 2008b ; UKONS, 2008; Schulmeister, 2009).

Guidance

- Treatment should be dependent on the pharmaceutical manufacturer's guidelines, the properties of the extravasated agent and the severity of the extravasation (CP Pharmaceuticals, 1999; Stanley, 2002).
- If a vesicant medication has extravasated, treatment should be determined prior to catheter removal (Stanley, 2002).
- Ongoing observation and assessment of the extravasated site should be performed and documented in the patient's medical record.
- An extremity should not be used for subsequent vascular access device placement when extravasation of a vesicant agent has occurred (INS, 2006).
- The doctor should be notified when an extravasation occurs.
- A critical incident form as well as specific extravasation documentation should be completed.
- Extravasation statistics (to include frequency, severity, and type of infusate) should be maintained within the trust and nationally by using the green card reporting system (Stanley, 2002).

Websites

The National Extravasation Information Service:
www.extravasation.org.uk

9.4 Haematoma

Standard

Haematoma will be defined as uncontrolled bleeding at a puncture site, usually creating a hard painful swelling filled with infiltrated blood (Lamb and Dougherty, 2008). It can result following puncture of a vein or an artery.

Statistics on incidence, degree, cause and corrective action taken for haematoma should be maintained and readily retrievable.

The practitioner should be competent to assess the access site and determine the need for treatment and/or intervention in the event of haematoma.

Guidance

- The organisation should have guidelines regarding the prevention of haematoma.
- The practitioner should perform a risk assessment in order to identify individuals who may be particularly susceptible to haematoma formation, including older people, those having anticoagulation therapy and children (Lamb and Dougherty, 2008).
- Strategies to minimise the risk of haematoma should be employed. These should include the use of optimal pressure to the puncture site following a failed procedure or removal of a vascular access device, and the practitioner should have the appropriate level of expertise for insertion of the device (Perucca, 2009; Lamb and Dougherty, 2008).
- The nurse should have knowledge of the management of haematoma including the use of pharmacological methods such as Hirudoid™ cream (BMA and RPS, 2008) and observing limb perfusion to avoid perfusion injury following an arterial haematoma.
- Incidence of haematoma, together with cause and its treatment, should be recorded in the patient's notes, so that possible steps for future prevention can be identified.

9.5 Haemorrhage

Standard

An incidence of haemorrhage should be reported as an adverse patient outcome.

The practitioner must be competent to identify haemorrhage and employ appropriate strategies to minimise blood loss/arrest bleeding (Scales, 2008a).

All information relating to the event should be documented in the patient's nursing and medical notes (NMC, 2005).

Guidance

- All organisations must have a policy relating to the recognition, prevention, management and reporting of haemorrhage (BSCH, 2006).

- Assessment of the risk of haemorrhage should be made. Risk factors include, but are not limited to, the patient's health status, anticoagulant therapy and the chosen access site (Scales, 2008a).
- Observation of haemorrhage occurrence should prompt immediate treatment to arrest bleeding/minimise blood loss whilst adhering to standard precautions.
- Treatment should be dependent on the cause/site of the bleeding.
- Ongoing observation and assessment of the haemorrhage site should be performed and documented.
- Details of the cause and action taken should be documented in the patient's record (NMC, 2005).

9.6 Pneumothorax and haemothorax

Standard

An incidence of pneumothorax/haemothorax associated with vascular access should be reported as an adverse patient outcome.

The practitioner should be competent to identify pneumothorax/haemothorax and determine the need for treatment and/or intervention.

All information relating to the event should be documented in the patient's nursing and medical notes.

Guidance

- The practitioner should demonstrate knowledge of the relevant anatomy for the insertion of central venous catheters (Scales, 2008).
- Strategies to minimise the risk of pneumothorax/haemothorax should be employed including, but not limited to, choice of venous access site, optimal patient positioning and respiratory pause and use of ultrasound imaging (NICE, 2002).
- Radiological determination of the catheter placement, following insertion, should be made and documented (Wise *et al.*, 2001).
- Treatment should be dependent on the needs of the individual patient.

- Information relating to the cause, action taken and outcome of the event should be documented in the patient's record (NMC, 2008b).

9.7 Cardiac tamponade

Standard

An incidence of cardiac tamponade associated with vascular access should be reported as an adverse patient outcome.

The practitioner should be competent to identify the acutely ill patient following a possible tamponade and take appropriate action (NICE, 2007; NPSA, 2007h).

All information relating to the event should be documented in the patient's nursing and medical notes.

Guidance

- Assessment of the risk of tamponade should be carried out by a skilled professional. Risk factors include, but are not limited to, the patient's health status, anticoagulant therapy, and the procedure being performed. Tamponade is associated with central venous catheters and can occur on insertion or subsequently, particularly if the catheter is placed in the heart chambers (Scales 2008a).
- The practitioner should demonstrate knowledge of the signs and symptoms of tamponade (Smeltzer and Bare, 2000).
- Observation of the signs and symptoms of tamponade occurrence should prompt immediate treatment to relieve cardiac compression (Smeltzer and Bare, 2000).
- Ongoing observation and assessment of the patient should be performed and documented.
- Information relating to the cause, action taken and outcome of the event should be documented in the patient's record (NMC, 2008b).
- Incidence of tamponade, together with the cause, should be recorded so that possible steps for future prevention can be identified.

9.8 Air embolus

Standard

Measures must be employed to avoid air embolus when inserting, removing and accessing vascular access devices.

The insertion and removal of vascular access devices must be performed by a trained health care professional with the experience, knowledge and skills to perform this procedure.

Guidance

- A protocol for the insertion, removal and use/access of vascular access devices should be established in organisational policies and procedures.
- A health care professional with the appropriate training, experience, knowledge and skills should be responsible for the insertion and removal of venous access devices.
- Practitioners caring for patients with vascular access devices should be aware of the potentially lethal complications of air embolus associated with the use of central venous catheters (Heckmann *et al.*, 2000a).
- Practitioners should know how to recognise an air embolism and the action to be taken to manage air embolism (Scales, 2008a).
- The patient should be placed where possible in the Trendelenburg position during insertion of central venous access devices in the large veins in the upper part of the body (Scales, 2008a; Bodenham & Simcock, 2009).
- During the insertion procedure the end of the catheter should be occluded when guidewires or syringes are removed (Scales, 2008a).
- Ideally the patient undergoing elective insertion of a central venous access device insertion should not be hypovolaemic (Scales, 2008a).
- To avoid air embolism during PICC insertion the patient's arm should be kept below the level of the heart (Richardson and Brusio, 1993; Bodenham and Simcock, 2009).

- Central venous access devices placed in the large veins in the upper part of the body should be removed with the patient supine or in the Trendelenburg position. The catheter should be removed while the patient performs the Valsalva manoeuvre (forced expiration with the mouth closed) or following inspiration if the patient is unable to perform this technique (Drewett, 2000; Weinstein, 2007; Hopwood, 2008; Scales, 2008a).
- Caution should be used in the removal of vascular access devices, including precautions to prevent air embolism; gentle digital pressure should be applied to the exit site and vein entry site until haemostasis is achieved; and a sterile occlusive, airtight (air-impermeable) dressing should be applied to the access site immediately on catheter removal. The dressing should remain in situ for 72 hours (Drewett, 2000; INS, 2006; Hopwood, 2008; Scales, 2008a).
- Air-in-line detectors should be used to monitor for air bubbles in administration sets when delivered via an electronic infusion device (MDA, 2008a; Lamb and Dougherty 2008).
- Air should be 'purged' from administration sets and extension tubing prior to attachment to a vascular access device (Weinstein, 2007; Lamb and Dougherty, 2008; Hopwood, 2008).
- All equipment used with vascular access devices should be Luer-Lok™ to minimise the risk of disconnection (Weinstein, 2007; Lamb and Dougherty, 2008; Hopwood, 2008).
- The in-line clamp or an external clamp should be used to close the catheter when changing equipment, for example end caps and administration sets (Hopwood, 2008).
- Infusion bags and containers should not be allowed to run dry/empty during an infusion (Weinstein, 2007).

9.9 Speedshock/fluid overload

Standard

The administration of medication and/or infusion should be performed in accordance with manufacturers' recommendations and the organisation's policy/procedure in order to prevent

the development of speedshock and fluid overload (NPSA, 2007b; Hopwood, 2008).

Guidance

- The nurse administering the medication and/or infusion should have the knowledge of the speed or rate over which to perform administration (Lamb and Dougherty, 2008).
- The nurse should be able to prevent the occurrence and recognise the signs and symptoms of speedshock and overloading (Lamb and Dougherty, 2008).
- Should either occur, the nurse must be able to act accordingly and the doctor should be notified.

9.10 Infusion-related bloodstream infections

Standard

Blood stream infections are serious infections that increase patient morbidity. They are frequently associated with the use of IV devices and can result in secondary infections such as osteomyelitis and endocarditis.

The nurse should be aware of the risks of infusion-related bloodstream infections and how to prevent them occurring (Weinstein, 2007).

Nurses should be aware of the signs and symptoms of blood stream infections in order to prompt investigation and action if required.

When an infusion-related infection is suspected, blood samples, the catheter tip, the access site and the infusate (if it is suspected as a source of sepsis) should be cultured using aseptic technique and observing standard precautions (INS, 2006).

Guidance

- Protocols for the management of septicaemia should be set out in organisational policies and procedures.
- When intrinsic contamination is suspected, the pharmacy, the manufacturer and the MHRA should be notified.
- Consideration should be given to obtaining blood cultures through the suspected device as well as

via peripheral venepuncture in order to identify and compare the proliferation of infusion-related infection (INS, 2006).

9.11 Thrombosis

Standard

Thrombosis is the formation of a blood clot within a blood vessel (Weinstein, 2007).

Statistics on incidence, degree, cause and corrective action taken for thrombosis associated with vascular access should be maintained and readily retrievable.

The nurse must be competent to identify peripheral venous thrombosis secondary to peripheral cannulation or drug administration.

The nurse must be competent to identify central venous thrombosis secondary to central venous catheter insertion or treatments related to the access device.

All information relating to the event should be documented in the patient's nursing and medical notes (NMC, 2005).

Guidance

- Protocols for the management of thrombosis should be set out in organisational policies and procedures.
- The nurse should demonstrate knowledge of the anatomy associated with peripheral and central venous access devices.
- The nurse should demonstrate knowledge of the causative factors related to the development of a thrombosis such as underlying disease, catheter material, tip location, treatment and previous history (Moureau *et al.*, 1999; Vesely, 2003).
- The nurse should be aware of the strategies to minimise the risk of peripheral and central venous thrombosis, e.g. the use of warfarin (Bern *et al.*, 1990; Mayo, 2001a; Couban *et al.*, 2005; Young *et al.*, 2005; Rawson and Newburn-Cook, 2007).
- The nurse should observe for secondary effects, e.g. pulmonary embolism, limb perfusion.

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Appendix 1: Phlebitis scale

Policy statement

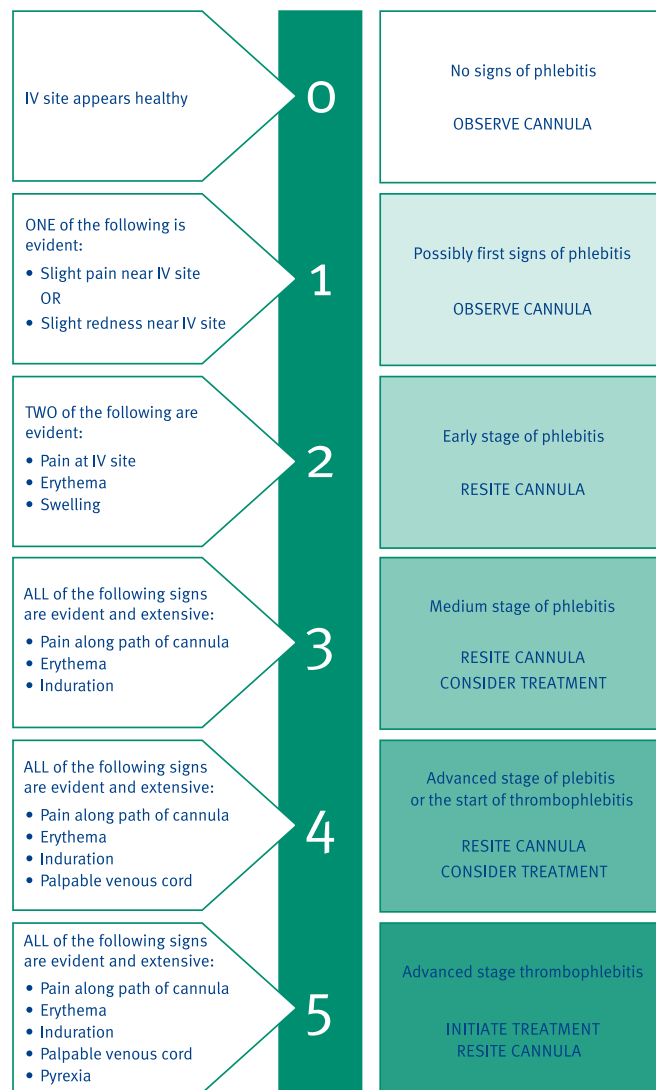
All patients with an intravenous peripheral access device in place, must have the IV site checked at least daily for signs of infusion phlebitis. The subsequent score and action(s) taken (if any) must be documented.

The cannula site must also be observed when:

- bolus injections are administered
- IV flow rates are checked or altered
- solution containers are changed.

The incidence of infusion phlebitis varies, the following Good Practice Points may assist in reducing the incidence of infusion phlebitis:

- observe cannula site at least daily
- secure cannula with a proven intravenous dressing
- replace loose, contaminated dressings
- cannula must be inserted away from joints whenever possible
- aseptic technique must be followed
- consider re-siting the cannula every 72-96 hours
- plan and document continuing care
- use the smallest gauge cannula most suitable for the patient's need
- replace the cannula at the first indication of infusion phlebitis (stage 2 on the VIP Score).



(Jackson, 1998)

Appendix 2: Infiltration scale

Grade	Clinical criteria
0	<ul style="list-style-type: none"> • No symptoms
1	<ul style="list-style-type: none"> • Skin blanched • Oedema <1 inch (2.5cm) in any direction • Cool to touch • With or without pain
2	<ul style="list-style-type: none"> • Skin blanched • Oedema 1–6 inches (2.5cm–15cm) in any direction • Cool to touch • With or without pain
3	<ul style="list-style-type: none"> • Skin blanched, translucent • Gross oedema >6 inches (15cm) in any direction • Cool to touch • Mild to moderate pain • Possible numbness
4	<ul style="list-style-type: none"> • Skin blanched, translucent • Skin tight, leaking • Skin discoloured, bruised, swollen • Gross oedema >6 inches (15cm) in any direction • Deep pitting tissue oedema • Circulatory impairment • Moderate to severe pain • Infiltration of any amount of blood product, irritant, or vesicant

(INS, 2006)

Appendix 3: Calculation formulae

Drug calculation

$$\frac{\text{WANT}}{\text{GOT}} \quad \times \quad \text{Stock}$$

$$\frac{\text{What you WANT}}{\text{What you've GOT}} \quad \times \quad \text{Stock}$$

Gravity flow

$$\frac{\text{VOLUME}}{\text{TIME}} \quad \times \quad \frac{\text{Drops per ml}}{60}$$

$$\frac{\text{VOLUME in ml}}{\text{HOURS of infusion}} \quad \times \quad \frac{\text{Drops per ml}}{60}$$

Appendix 4: Useful organisations

The National Patient Safety Agency

The National Patient Safety Agency (NPSA) is a special health authority created to co-ordinate nationwide efforts to report and, more importantly, to learn from, adverse events and near misses occurring in the NHS. The NPSA will play a key role in raising standards of patient care and making them consistent across the country by implementing a national reporting system encouraging staff, patients and carers to report mistakes. This information will enable the NPSA to initiate preventive measures so that the whole country can learn from each case, and improve patient safety throughout the NHS. As well as making sure events are reported in the first instance, the NPSA will promote a more open and fair culture in the health service, encouraging NHS staff to report incidents without fear of personal reprimand.

The NPSA will promote patient safety by:

- establishing and managing a national reporting and learning system for adverse events and near misses
- assimilating safety-related information from other organisations
- designing solutions that prevent harm
- setting targets and monitoring progress
- promoting research
- advising ministers and others on patient safety issues
- promoting an open and fair culture in the NHS
- developing memoranda of understanding with other key health care organisations that have an interest or involvement in patient safety.

Contact details:

National Patient Safety Agency
4–8 Maple Street
London W1T 5HD
Telephone: +44 (0)20 7927 9500
Fax: +44 (0)20 7927 9501
Email: enquiries@npsa.nhs.uk
Web: www.npsa.nhs.uk

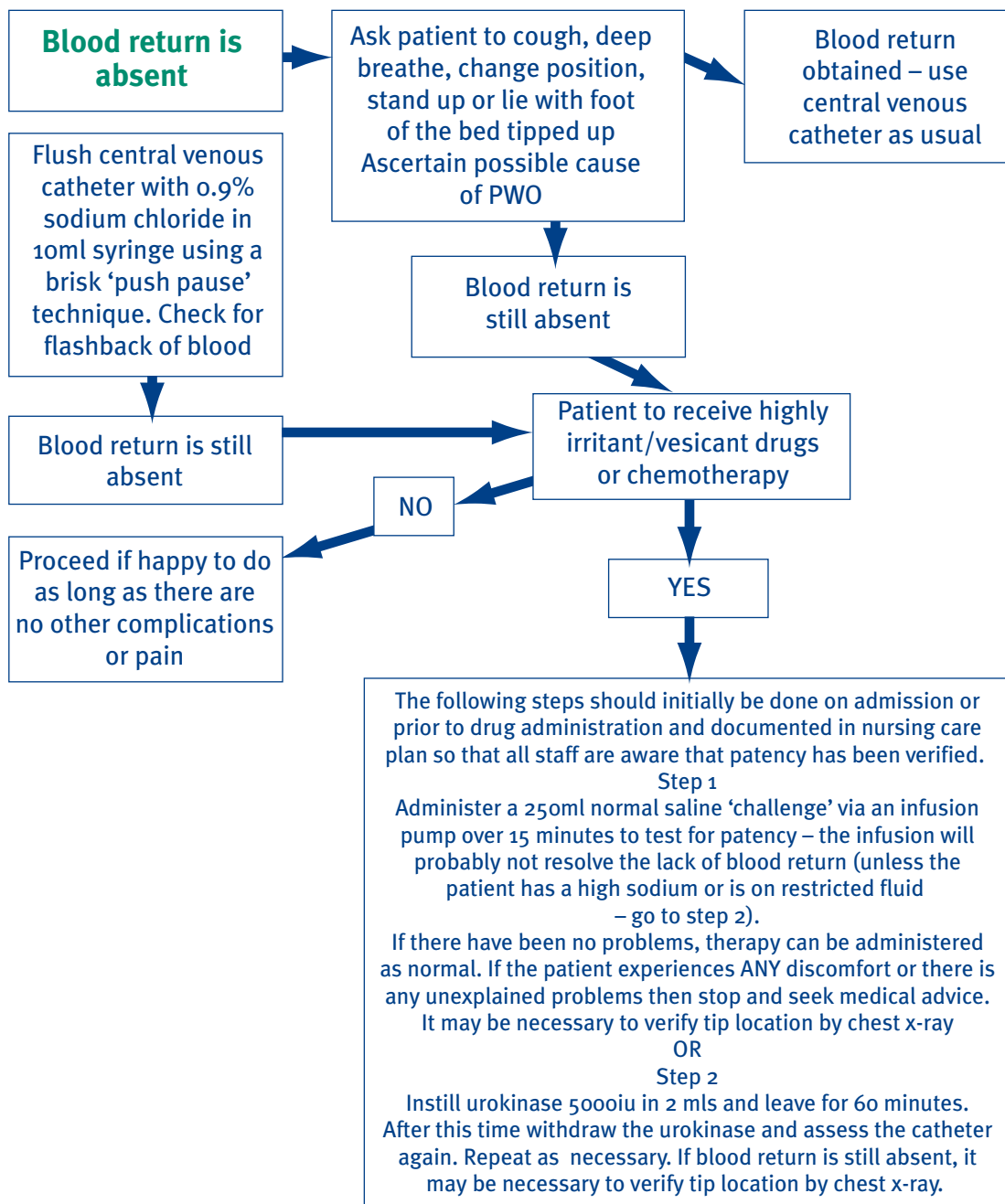
MHRA

The Medicines and Health care Products Regulatory Agency (MHRA) is the government agency which is responsible for ensuring that medicines and medical devices work, and are acceptably safe. It also oversees the safety and quality of human blood and blood components. The MHRA encourages nurses and other health care professionals to report problems with medicines, medical devices or blood products so that they can be investigated and any necessary action taken. Details of how to report, including on-line reporting and important safety information is available via the MHRA website. www.mhra.gov.uk

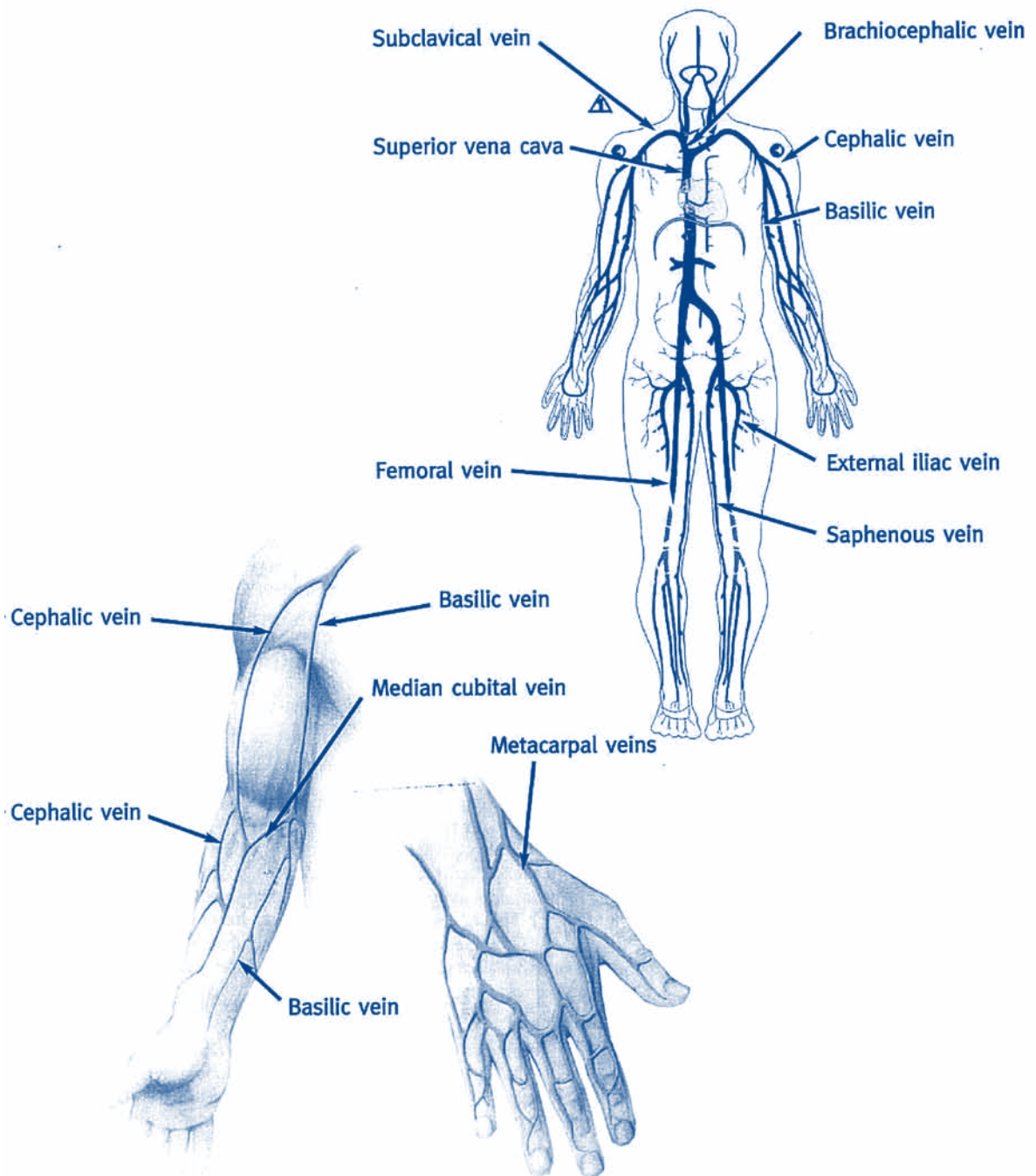
The agency can also be contacted on 020 7084 2000.

Appendix 5: Algorithm persistent withdrawal occlusion

i.e. fluids can be infused freely by gravity but blood cannot be withdrawn from the catheter (London Standing Committee 2000)



Appendix 6: Vein Diagrams



Appendix 7: Examples of audit tools that can be used for infusion therapy

Key audit criteria identified in the guidelines for preventing infections associated with the use of central venous access devices and standard principles for preventing health care-associated infections in hospital and other acute settings (Pratt *et al.*, 2007):

- high-impact interventions 1 and 2 review tools
- RCN Intravenous Therapy Forum audit tool for peripheral venous cannula
- Infection Control Nurses Association audit tool for IV insertion and management and audit tool for organisational structures for IV management (ICNA, 2001).

Other resources

National Institute for Clinical Excellence (2002) *Principles for best practice in clinical audit*. Oxford: Radcliffe Medical Press Ltd.

Appendix 8: Issues in clinical practice

Checking for blood return to confirm patency prior to the administration of medications and/or solutions.

This issue has been the subject of much discussion and debate both before and since the publication of the *RCN Standards for infusion therapy* in 2003 and again in 2005. The Standards state that “the nurse should aspirate the catheter and check for blood return to confirm patency prior to the administration of medications and/or solution” (INS, 2006). There is a very useful algorithm (Appendix 4 to follow, if blood cannot be withdrawn from the catheter but fluids can be infused freely by gravity (Dougherty, 2006).

This issue is particularly challenging for nurses working in the community as they do not have medical and nursing colleagues readily available to ask for advice if they are unable to get a blood return. Therefore whilst checking for blood return prior to the administration of medication and/or infusions is best practice generally, and essential if vesicant drugs are to be administered, there are also a number of

other equally important issues that should be taken into account:

1. Information provided about the VAD

- The exact position of the catheter tip should be known and documented.
- Whether the hospital has ever been able to get a blood return from the catheter.
- Information about the VAD including possible complications and the signs and symptoms of these.

2. A thorough patient assessment should be carried out each time a nurse visits to administer any IV medication and/or infusion. This should include:

- asking the patient if they have any pain, discomfort, swelling in the area of the VAD or if they are experiencing any new/different symptoms
- asking the patient if they have pulled or caught the catheter
- measuring the length of the external portion of the catheter at each visit to ensure it remains the same, and documenting the length
- checking the exit site and surrounding area to ensure there is no visible swelling, exudate, redness or signs of infection.

3. Knowing about the medication/infusion that is to be administered:

- is the drug a vesicant or hyperosmolar solution?
- what is the pH and osmolarity of the drug?
- how should it be given, i.e. via a centrally placed catheter? (Kayley and Finlay, 2003).

It is important that all the relevant information and each patient assessment is clearly documented even if nothing abnormal is detected. If the community nurse is concerned about any aspect of the assessment then advice should be sought from the referring hospital unit or community IV specialist nurse (if appropriate). If a routine flush to maintain patency of the VAD is being carried out, then there is no requirement to routinely withdraw blood and discard it prior to flushing (except prior to blood sampling, but not blood cultures).

Appendix 9: Glossary

Air embolism: Presence of air in the vascular system. Venous air embolism may occur during insertion, use or maintenance of a central venous catheter and after catheter disconnection and removal (Heckmann *et al.*, 2000). Symptoms of air embolism include shortness of breath, altered consciousness, visual disturbance, hemiparesis, chest pain and a low cardiac output state.

Allen's test: Test performed on radial artery prior to arterial puncture to ascertain adequate arterial perfusion.

Ambulatory infusion device: Electronic infusion device specifically designed to be worn on the body to promote patient mobility and independence.

Amino acids: Organic components of protein.

Ampoule: Hermetically sealed glass medication container which must be broken at the neck to access the medication.

Anastomosis: Surgical formation of a passage between two normally distant structures, for example two blood vessels.

Anti-free-flow administration set: An administration set that stops when removed from the infusion device, yet allows gravity flow when the user manipulates the regulatory mechanism.

Antimicrobial: Preventing or destroying the growth and development of micro-organisms.

Apheresis: Apheresis involves the separation and subsequent collection of one or more blood components. Apheresis procedures include platelet depletion, therapeutic plasma exchange, red cell exchange, rapid red cell transfusion, white blood cell (mononuclear cell or polymorphonuclear cell) procedures and peripheral blood stem cell procedures.

Arterial pressure monitoring: Monitoring of arterial pressure through an in-dwelling arterial catheter connected to an electronic monitor.

Arteriovenous (AV) fistula: Surgical procedure to join an artery to a vein in order to create an internal site for haemodialysis access. Over time the pressure from the arterial blood entering the vein will cause the vein to enlarge in order to accommodate fistula needles.

Aseptic technique: Mechanisms employed to reduce potential contamination.

Bacteria: Micro-organisms that may be non-pathogenic (normal flora) or pathogenic (disease-causing).

Body surface area: Surface area of the body expressed in square metres. Used in calculating paediatric dosage, managing burn patients and determining radiation and chemotherapy dosage.

Bolus: Concentrated medication and/or solution given rapidly over a short period of time.

Cannula: Hollow tube made of silastic, rubber, plastic or metal, used for accessing the body.

Cardiac tamponade: The effusion of blood, air or pus into the pericardial sac, causing compression of the heart.

Catheter: Tube for injecting or evacuating fluids.

Catheter dislodgement: Movement of the catheter into and out of the insertion site. Causes of catheter dislodgement include inappropriate securing of the catheter, and motion of the extremity, neck or shoulder. Catheter dislodgement may cause occlusion of the catheter and lead to a change in the catheter tip location. Signs and symptoms of catheter dislodgement include changes in the external length of the catheter, clinical signs of local catheter infection, and inability to flush or infuse via the catheter.

Central venous catheter: Catheter inserted into a centrally located vein with the tip residing in the vena cava; permits intermittent or continuous infusion and/or access into the venous system.

Chemical incompatibility: Change in the molecular structure or pharmacological properties of a substance that may or may not be visually observed.

Closed system: Administration system with no mechanism for external entry after initial set-up and assembly.

Colour coding: System developed by manufacturers that identifies products and medications by the use of a colour system. Colour code systems are not standardised. Each manufacturer uses different colour code systems.

Compatibility: Capability to be mixed and administered without undergoing undesirable chemical and/or physical changes or loss of therapeutic action.

Conscious sedation: Minimally depressed level of consciousness in which the patient retains the ability to maintain a patent airway independently and continuously, and to respond appropriately to physical stimulation and verbal commands. The drugs, doses and techniques used are not intended to produce loss of consciousness.

Contamination: Introduction or transference of pathogens or infectious material from one source to another.

Criteria: Relevant, measurable indicators.

Critical or adverse incident: An event or omission arising during clinical care and causing physical or psychological injury to a patient.

Cross-contamination: Movement of pathogens from one source to another.

Curative: Having healing or remedial properties.

Cutdown: Surgical procedure for locating a vein or artery.

Delivery system: Product that allows for the administration of medication. The system can be integral or can have component parts and includes all products used in the administration, from the solution container to the catheter.

Disinfectant: Agent that eliminates all micro-organisms except spores.

Distal: Furthest from the centre or midline of the body or trunk, or furthest from the point of attachment; the opposite of proximal.

Distention: An increase in size because of pressure from within; stretching or inflation.

Document: Written or printed record containing original, official or legal information.

Documentation: Record in written or printed form, containing original, official or legal information.

Dome: Plastic component used in haemodynamic monitoring.

Electronic infusion device (EID): Electronic instrument, either a pump (that is, positive pressure) or controller (that is, gravity-fed), used to regulate the flow rate of the prescribed therapy; often referred to as an electronic flow-control device.

Embolus: Mass of undissolved matter present in blood or lymphatic vessel. Embolus may be solid, liquid or gaseous.

Epidemiology: Study of the distribution and determinants of health-related states and events in populations; defines and explains the relationship between host, agent and environment.

Epidural space: Space superior to the dura mater of the brain and the spinal cord and inferior to the ligamentum flavum.

Epithelialised: Grown over with epithelial cells; said of a wound or catheter site.

Erythema: Redness of skin along vein track that results from vascular irritation or capillary congestion in response to irritation; may be a precursor to phlebitis.

Extravasation: Inadvertent infiltration of vesicant solution or medication into surrounding tissue; rated by a standard scale.

Extrinsic contamination: Contamination that occurs after the manufacturing process of a product.

Fat emulsion (lipid emulsion): Combination of liquid, lipid and an emulsifying system suitable for intravenous use.

Filter: Special porous device used to prevent the passage of air or other undesired substances; product design determines size of substances retained.

Fluid overload: A fluid and electrolyte imbalance caused by the volume of fluid infusion into a patient.

Free flow: Non-regulated, inadvertent administration of fluid.

Grade: Degree of standing or value.

Haemodynamic pressure monitoring: General term for determining the functional status of the cardiovascular system as it responds to acute stress such as myocardial infarction and cardiogenic or septic shock. A pulmonary artery catheter is used to directly measure intracardiac pressure changes, cardiac output, blood pressure and heart rate.

Haemolysis: Destruction of the membrane of the red blood cells resulting in the liberation of haemoglobin, which diffuses into the surrounding fluid.

Haemostasis: Arrest of bleeding or of circulation.

Haemothorax: The presence of blood in the pleural space.

Hypertonic: Solution of higher osmotic concentration than that of a reference solution or of an isonic solution; having a concentration greater than the normal tonicity of plasma.

Hypodermoclysis: Injection of fluids into the subcutaneous tissues to supply the body with liquids quickly.

Hypotonic: Solution of lower osmotic concentration than that of a reference solution or of an isotonic solution; having a concentration less than the normal tonicity of plasma.

Immunocompromised: Having an immune system with reduced capability to react to pathogens or tissue damage.

Immunoglobulin therapy: Intravenous immunoglobulin (IVIG) has been used in the treatment of primary and secondary antibody deficiencies for more than 20 years. IVIG has also been used to treat a variety of autoimmune or allergic diseases. IVIG is produced from human blood plasma pooled from many individual donations. Both the plasma donor and the donation are screened for clinically significant viruses. During production of IVIG, steps are taken to inactivate or remove any infectious agents (Lee *et al.*, 2000). The mechanism of IVIG action is unknown. IVIG is usually administered on a monthly basis but can be given every two to three weeks.

Implanted port: A catheter surgically placed into a vessel or body cavity and attached to a reservoir located under the skin.

Implanted pump: A catheter surgically placed into a vessel or body cavity and attached to a reservoir located under the skin that contains a pumping mechanism for continuous medication administration.

Incompatible: Incapable of being mixed or used simultaneously without undergoing chemical or physical changes or producing undesirable effects.

Infection: Presence and growth of a pathogenic micro-organism.

Infiltration: Inadvertent administration of a non-vesicant solution or medication into surrounding tissue; rated by a standard scale.

Infusate: Parenteral solution administered into the vascular or non-vascular systems; infusion.

Injection access site: Resealable cap or other configuration designed to accommodate needles or needle-less devices for administration of solutions into the vascular system.

Intact system: A closed infusion system.

Intermittent intravenous therapy: Intravenous therapy administered at prescribed intervals with periods of infusion cessation.

Intraosseous: Within the bone substance. The intraosseous route is an alternative for intravenous access in the critically ill or injured patient. This route is used for emergency drug administration, fluid resuscitation and access to the vascular system in situations where conventional routes cannot be utilised or would cause delays in treatment. The intraosseous access needle consists of a needle and stylet such as a standard bone marrow needle. The intraosseous access needle is advanced through the skin to the bony cortex where the needle is further advanced into the marrow cavity. The stylet is then removed prior to use. Any drug administered intravenously can be given via the intraosseous route.

Intrathecal: Within the spinal canal.

Intrathecal chemotherapy: The administration of cytotoxic drugs into the central nervous system via the cerebrospinal fluid by means of a lumbar puncture. Used in the treatment of leukaemia and lymphoma. Only thiotepea, cytarabine, methotrexate, hydrocortisone and interferon may be administered by this route.

Intraventricular access device: The Ommaya reservoir is an implanted ventricular access device that enables the delivery of drugs directly into the central nervous system. The Ommaya reservoir consists of a mushroom-shaped, self-sealing silicone port that is placed subcutaneously underneath a scalp flap, usually in the frontal region. A ventricular catheter is attached to the reservoir and inserted into the lateral ventricle to provide access to the cerebrospinal fluid.

Intrinsic contamination: Contamination that occurs during the manufacturing process of a product.

Investigational drug: Drug undergoing investigation for a specific use via a clinical trial to determine its safety and effectiveness in humans.

Irritant: Agent capable of producing discomfort or pain at the venepuncture site or along the internal lumen of the vein.

Isolation: Separation of potentially infectious individuals for the period of communicability to prevent or limit direct or indirect transmission of the infectious agent.

Isotonic: Having the same osmotic concentration as the solution with which it is compared (that is, plasma).

Laminar flow hood: Contained workstation with filtered air flow; assists in preventing bacterial contamination and collection of hazardous chemical fumes in the work area.

Lipid emulsion: See fat emulsion.

Lumen: Interior space of a tubular structure, such as a blood vessel or catheter.

Lymphoedema: Swelling caused by obstruction of the lymphatic vessel(s).

Manual flow-control device: Manually operated device to control the flow rate of the infusion.

Maximal barrier protection: Equipment and clothing used to avoid exposure to pathogens, including mask, gown, protection eyewear, cap, sterile gloves, sterile drapes and towels.

Medical act: Procedure performed by a licensed physician.

Microabrasion: Superficial break in skin integrity that may predispose the patient to infection.

Microaggregate: Microscopic collection of particles such as platelets, leukocytes and fibrin that occurs in stored blood.

Microaggregate blood filter: Filter that removes microaggregates and reduces the occurrence of non-haemolytic febrile reactions.

Micron (μ): Unit of length equal to one-millionth of a metre, or one-thousandth of a millimetre.

Micro-organism: Minute living body not perceptible to the naked eye.

Midline catheter: A midline catheter is a device that is inserted via the antecubital veins and advanced into the veins of the upper arm but not extending past the axilla (usually about 20cm in length).

Milliosmole (mOsm): One-thousandth of an osmole; osmotic pressure equal to one-thousandth of the molecular weight of a substance divided by the number of ions that the substance forms in a litre of solution.

Morbidity rate: Number of infected individuals or cases of disease in relation to a specific population.

Mortality rate: Death rate; ratio of number of deaths in a population to number of individuals in that population.

Multiple-dose vial: Medication bottle that is hermetically sealed with a rubber stopper and is designed to be used more than once.

Needle-less system: Substitute for a needle or a sharp access catheter, available in various designs, for example blunt, recessed and valve.

Needlestick injury: Needlestick injuries are wounds caused by needles that accidentally puncture the skin. Needlestick injuries are a hazard for people who work with needles and other sharps equipment. These injuries can occur at any time when people use, handle or dispose of needles. When not disposed of properly, needles can become concealed in linen or waste and injure other workers who encounter them unexpectedly. Needlestick injuries transmit infectious diseases, especially bloodborne viruses.

Non-permeable: Able to maintain integrity.

Non-vesicant: Intravenous medication that generally does not cause tissue damage or sloughing if injected outside a vein.

Occluded: Blocked because of precipitation of infusate, clot formation or anatomic compression.

Osmolality: Characteristic of a solution determined by the ionic concentration of the dissolved substances per unit of solvent; measured in milliosmoles per kilogram.

Osmolarity: Number of osmotically active particles in a solution.

Outcome: Interpretation of documented results.

Palliative: Relieving or alleviating without curing.

Palpable cord: Vein that is rigid and hard to the touch.

Palpation: Examination by application of the hands or fingers to the external surface of the body in order to detect evidence of disease or abnormalities in the various organs.

Parenteral: Administered by any route other than the alimentary canal, for example by the intravenous, subcutaneous, intramuscular or mucosal routes.

Parenteral nutrition: Intravenous provision of total nutritional needs for a patient who is unable to take appropriate amounts of food enterally; typical components include carbohydrates, proteins and/or fats, as well as additives such as electrolytes, vitamins and trace elements.

Particulate matter: Matter relating to or composed of fine particles.

Pathogen: Micro-organism or substance capable of producing disease.

Peripherally inserted central catheter (PICC): Soft, flexible, central venous catheter inserted into an extremity and advanced until the tip is positioned in the lower third of the superior vena cava.

pH: Degree of acidity or alkalinity of a substance.

Pharmacology: Concerns the actions of medicines in the body.

Pharmaceutics: Concerns the formulation, manufacture/preparation, stability and packaging of medicines.

Phlebitis: Inflammation of a vein; may be accompanied by pain, erythema, oedema, streak formation and/or palpable cord; rated by a standard scale.

Phlebotomy: Withdrawal of blood from a vein.

Physical incompatibility: Undesirable change that is visually observed within a solution.

PICC: See Peripherally inserted central catheter.

Pneumothorax: The presence of air between the pleura.

Policy: Written statement describing a course of action; intended to guide decision-making.

Positive pressure: Constant, even force within a catheter lumen that prevents reflux of blood; achieved by clamping while injecting or by withdrawing the needle from the catheter while injecting.

Post-infusion phlebitis: Inflammation of the vein occurring after the infusion has been terminated and the catheter removed, usually identified within 48 hours after removal.

Pounds per square inch (PSI): Measurement of pressure. One PSI equals 50mmHg or 68cm H₂O.

Preservative-free: Containing no added substance capable of inhibiting bacterial contamination.

Procedure: Written statement of steps required to complete an action.

Process: Actual performance and observation of performance based on compliance with policies, procedures and professional standards.

Product integrity: Condition of an intact, uncompromised product suitable for intended use.

Proximal: Closest to the centre or midline of the body or trunk, or nearer to the point of attachment; the opposite of distal.

Psychomotor: Characterising behaviours that place primary emphasis on the various degrees of physical skills and dexterity as they relate to the thought process.

Purulent: Containing or producing pus.

Push: Manual administration of medication under pressure.

Quality assurance/performance improvement: An ongoing, systematic process for monitoring, evaluating and problem solving.

Radiopaque: Impenetrable to X-rays or other forms of radiation; detectable by radiographic examination.

Risk management: Process that centres on identification, analysis, treatment and evaluation of real and potential hazards.

Safety device system: Engineered physical attribute of a device that effectively reduces the risk of bloodborne pathogen exposure.

Scale: Tool to measure gradations.

Sclerosis: Thickening and hardening of the layers in the wall of the vessel.

Semi-quantitative culture technique: Laboratory protocol for isolating and identifying micro-organisms.

Sepsis: Presence of infectious micro-organisms or their toxins in the bloodstream.

Sharps: Objects in the health care setting that can be reasonably anticipated to penetrate the skin and to result in an exposure incident, including but not limited to needle devices, scalpels, lancets, broken glass or broken capillary tubes.

Single-use vial: Medication bottle that is hermetically sealed with a rubber stopper and is intended for one-time use.

Site protection material: Material used to protect an infusion catheter insertion site.

Skin-tunnelled catheter: Vascular access device whose proximal end is tunnelled subcutaneously from the insertion site and brought out through the skin at an exit site.

Speedshock: The rapid uncontrolled administration of a drug, where symptoms occur as a result of the speed with which medication is administered rather than the volume of drug/fluid. This can therefore occur even with small volumes.

Standard: Authoritative statement enunciated and promulgated by the profession by which the quality of practice, service or education can be judged.

Standard precautions: Guidelines designed to protect workers with occupational exposure to bloodborne pathogens.

Statistics: Systematic collection, organisation, analysis and interpretation of numerical data.

Sterile: Free from living organisms.

Stylet: Rigid metal object within a catheter designed to facilitate insertion.

Surfactant: Surface-active agent that lowers the surface tension of fluid.

Surveillance: Active, systematic, ongoing observation of the occurrence and distribution of disease within a population and the events or conditions that alter the risk of such occurrence.

Tamper-proof: Unable to be altered.

Thrombolytic agent: Pharmacological agent capable of dissolving blood clots.

Thrombophlebitis: Inflammation of the vein in conjunction with formation of a blood clot (thrombus).

Thrombosis: Formation, development or existence of a blood clot within the vascular system.

Transfusion therapy: A transfusion consists of the administration of whole blood or any of its components to correct or treat a clinical abnormality.

Transducer: Device that converts one form of energy to another.

Transparent semi-permeable membrane (TSM): Sterile, air-permeable dressing that allows visual inspection of the skin surface beneath it; water-resistant.

Vesicant: Agent capable of causing injury when it escapes from the intended vascular pathway into surrounding tissue.

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[†] The V-Link device is contraindicated for individuals with hypersensitivity to silver or silver components



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From the authors

Welcome to the third edition of the *Standards for infusion therapy*. We have concentrated on updating sections and references, but we have also changed the order to improve the flow of information.

**November 2005, reprinted with minor
amends June 2007, third edition
January 2010**

The RCN represents nurses and nursing,
promotes excellence in practice and shapes
health policies

Published by the Royal College of Nursing
20 Cavendish Square
London
W1G 0RN

RCNDirect

www.rcn.org.uk/direct
0345 772 6100

RCNOnline

www.rcn.org.uk

Publication code 002 179

ISBN 978-1-906633-19-6