Periprocedural Care in Pediatric Interventional Radiology

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Introduction

This chapter will focus on the clinical aspects of delivery of patient care, from periprocedural assessment to discharge. Practices will vary from institution to institution so several different approaches and options are presented in this chapter. Many examples from pediatric interventional radiology (PIR), drawn from the authors' experience, are interspersed throughout the text to explain a point or to highlight differences between pediatrics and adult practices. Several tables are included, intended to be useful for quick reference, such as definitions of relevant clinical terms for PIR (Tables 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, and 2.10).

As outlined in Chap. 1, it is no longer standard of care for interventional radiology (IR) physicians to perform procedures and leave the entire care of the patient to their referring team [1–4]. Increasingly IRs are actively involved in the continuum of patient care, following their patients pre- and post-procedure, either in the capacity of a consulting service or assuming full responsibility with admitting privileges. Many IRs without admitting privileges are actively seeking to obtain such privileges.

Details of specific procedures are dealt with in individual chapters. This chapter will address the following general aspects of periprocedural care:

(a) Pre-procedure clinical care
(b) Clinical care during the procedure
(c) Post-procedure care

Pre-procedure Clinical Care

Patient Assessment

The requirement for pre-procedure assessment depends on the nature of the procedure to be undertaken and ranges from minimal (such as for a gastrostomy tube check) to full IR pre-procedure evaluation, as in a patient with complex vascular malformation seen in a multidisciplinary clinic (see Chap. 1). Much of the IR workload can be considered "service work," in which case IR provides a valuable supportive service for a large number of patients referred from a variety of specialties, for example, when providing central venous access for surgical and oncologic patients. In other instances, IR provides the definitive therapeutic

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M. Temple and F.E. Marshalleck (eds.), *Pediatric Interventional Radiology: Handbook of Vascular and Non-Vascular Interventions*, DOI 10.1007/978-1-4419-5856-3_2,

Table 2.1 Common terms, definitions, and calculations used in a pediatric practice

Term	Term	37 completed weeks to 41 weeks and 6 days
Premature	Preterm	<37 weeks
Low birth weight	LBW	<2,500 g
Very low birth weight	VLBW	<1,500 g
Extreme low birth weight	ELBW	<1,000 g
Small for gestational age	SGA	BW <10th percentile for GA
Large for gestational age	LGA	BW >90th percentile for GA
Absolute neutrophil count	ANC	White cell count x% that are neutrophils
Severe neutropenia		ANC $<0.5\times10^9$/L
Normal urine output		Infants and young children: 1.5–2 mL/kg/h
		Older children and adolescents: 1 mL/kg/h
Estimated body weight (in kg) based on child's age		Children 1–9 years: (age in years × 2) + 8
		Children >10 years: age in years × 3.3
Endotracheal tube size (internal diameter in mm)		Infants <1 year: 3.5 mm (uncuffed)
		Children 1–2 years: 4 mm (uncuffed)
		Children 2–10 years: 4 + (age/4) (uncuffed)
		Children 2–10: 3.5 + (age/4) (cuffed)
Hypothermia		Core temperature <35 °C

Table 2.2 American Society of Anesthesia—a physical status classification system [6]

ASA 1	Normal healthy patient
ASA 2	A patient with mild systemic disease
ASA 3	A patient with severe systemic disease
ASA 4	A patient with severe systemic disease that is a constant threat to life
ASA 5	A moribund patient who is not expected to survive without the operation
ASA 6	A declared brain-dead patient whose organs are being removed for donor purposes
Prefix "e"	Emergency

Table 2.3 Variations in laboratory values with maturity and age [8]

Test name	Age	Reference values
Activated partial thromboplastin time (APTT)	<3 month	25–35 s
	>3 month	23–35 s
INR	<3 month	0.9–1.6
	>3 month	0.9–1.1
Hemoglobin	<30 days	140–200 g/L
	1 month	115–180 g/L
	2 months	90–135 g/L
	3–11 months	100–140 g/L
	1–4 years	110–140 g/L
	5–13 years	120–160 g/L
	≥14 years female	120–153 g/L
	≥14 years male	140–175 g/L
Creatinine	≤6 days	19–90 µmol/L
	7–60 days	10–56 µmol/L
	2 months–5 years	<36 µmol/L
	6–9 years	<53 µmol/L
	10–13 years	<79 µmol/L
	≥14 years	<98 µmol/L
Glucose *	<1 year	2.5–5.5 mmol/L
	1–2 years	2.5–5.0 mmol/L
	3–11 years	2.8–6.1 mmol/L
	≥12 years	3.3–6.1 mmol/L

* 1 mmol/L = 18 mg/dL

procedure for a variety of conditions, such as embolization of an arteriovenous malformation. Irrespective of the type of procedure considered, clearly it is important to ensure that the IR procedure requested is indicated and appropriate for that individual patient and to weigh the risk factors or contraindications prior to undertaking the procedure. Making this assessment may necessitate an IR clinic or multidisciplinary clinic visit. At such a visit, a clinical history is taken, physical examination is performed, necessary imaging is reviewed, and any required specialty consultation, imaging, or blood work is organized.

Evaluation of Imaging

Careful evaluation of available imaging is important in order to confirm that the procedure, for example, a biopsy or abscess drainage, is technically possible and clinically appropriate. If there is any uncertainty about access, choice of modal-

Table 2.4 Fasting guidelines for GA or sedation (may vary slightly from institution to institution) [8]

Clear fluids	2 h
Breast milk	4 h
Infant formula/cow's milk	6 h
Solids	8 h

Table 2.5 Example "time-out" checklist

All team members to stop what they are doing and take part in time-out
• Staff present
– Operator(s)
– Anesthesiologist
– Nurse
– Technologist
• Patient name
• Patient identification
• Patient diagnosis/history
• Procedure to be performed
• Procedures by other services to be performed
• Written consent
• Correct site and correct side marked (on patient)
• Patient allergies
• Blood work reviewed
• Last menstrual period/pregnancy test results
• Prophylactic antibiotics
• Correct name on imaging equipment
• Correct orientation on equipment
• Correct side markers in place on equipment
• Radiation protection equipment in place
• Grid in/out
• Any potential adverse events expected
• Equipment for adverse events inside/outside of room
– Crash cart
– Blood warmer
– Blood products
– Warming lights/blankets for neonates
• Equipment for procedure in room
• Any other concerns or comments from any team member in room?

ity to be used, or suitability for the planned procedure, this can be resolved by pre-procedure "mapping" imaging, ideally performed by an interventionalist, with the very specific and focused questions below in mind (different than those asked in a standard diagnostic imaging exam):

(a) Is the lesion well visualized with this imaging modality, or is another modality required?
(b) Can the lesion be safely accessed percutaneously, avoiding interposed vessels and other relevant structures, such as bowel or pleura?
(c) What are the risks and benefits of different trajectories or angles?
(d) What level of sedation/anesthesia is required for this patient for this procedure?

Mapping imaging may involve ultrasound, fluoroscopy, CT, or a combination of imaging modalities (e.g., combination of US and fluoroscopy mapping to assess the feasibility of placing a gastrostomy tube in an infant with distorted abdominal anatomy post diaphragmatic hernia repair). Mapping will determine the imaging required (e.g., should US or CT be used to access a small peripheral pulmonary nodule for biopsy) [5]. Time taken for pre-procedural mapping is time well spent, as it improves the accuracy of procedure planning, decreases the need for last-minute changes to the plan, enables the case to be scheduled with the most suitable equipment (e.g., CT scanner if needed), and avoids the situation where the patient must be moved during a case or, even, the procedure canceled. In addition, an appointment for mapping gives the parents and child an opportunity to visit the IR department and meet members of the team. The results of the mapping imaging are shared with the referring physician and the family, and a plan to proceed (or not proceed) is reached. This visit also provides an opportunity to obtain informed consent well in advance of the procedure, which is preferable to obtaining written consent immediately prior to the procedure, as the more relaxed setting allows a more adequate consent process for the family.

Consultations

Specialty consultation may need to be arranged prior to a procedure. Most commonly this involves an anesthesia consultation, usually indicated in children with known airway difficulties, complex cardiopulmonary problems, or American Society of Anesthesiology (ASA) Class 4 or 5 (Table 2.2) [6]. Additional investigations if required by the anesthesiologist are arranged in advance of the

Table 2.6 Age-appropriate normal estimates of weight, endotracheal tube size, and vital signs [8, 24]

Age	Weight (kg) (approx)	HR awake	HR sleeping	RR	BP	ETT size
Birth	3.5	85–205	80–160	30–60	65/40	3.0–3.5
6 months	7.5	110–160	80–160	24–38	85/50	3.5–4.0
1 year	10	90–150	75–160	22–30	90/55	4.0
3 years	14	80–125	60–90	22–30	92/55	4.5
5 years	18	70–115	60–90	20–24	95/58	5.0–5.5
10 years	30–32	60–100	50–90	16–22	100/62	6.0–6.5
12 years	40	60–100	50–90	16–22	106/62	6.5
14 years	45	60–100	50–90	14–20	110/66	6.5–7.0

Table 2.7 Abnormal vital signs in infants and children [8, 24]

Age	Pulse rate/min	Blood pressure (systolic)	Respiratory rate/min
≤3 months	<80 or >200	<60 mmHg	<30 or >60
3–12 months	<80 or >180	<65 mmHg	<24 or >50
1–10 years	<60 or >150	<70 + (2 × age in years)	<22 or >40
• 10 years	<60 or >120	<90 mmHg	<12 or >30

procedure (e.g., in an acute setting, an ECG, cardiology consultation, and echocardiography in a patient with a large anterior mediastinal mass pre-biopsy to evaluate pulmonary artery and venous flows, vascular compression, as well as the cardiac ejection fraction) [7]. Other examples include an ophthalmology consultation to evaluate eyes/vision prior to management of a periorbital vascular malformation or a cardiology consult in a child with cardiac symptoms or signs.

Blood Analyses

Blood work is frequently requested as part of the pre-procedure workup, individualized to the patient and procedure risk factors. Common examples pertinent to a pediatric practice are included, and the normal, abnormal and variations of values with age are shown in Table 2.3 [8].

Hematology

- Complete blood count (hemoglobin, platelet, neutrophil counts): Normal ranges of hemoglobin vary with patient age and gestation, as well as with local laboratory ranges (sample values Table 2.3). Severe neutropenia (absolute neutrophil count $<0.5 \times 10^9$/L) in an immunosuppressed child may represent a relative contraindication for certain procedures, e.g., gastrostomy tube insertion.
- Coagulation screen (PTT, INR): Coagulation parameters vary with patient age and gestation (Table 2.3). Guidelines for acceptable values have been drafted for IR procedures in adults [9].
- Sickle cell testing for sickle cell disease: May be required to plan for pre-procedure hydration, oxygenation +/− transfusion [10].
- Blood products: Consider type and screen if bleeding is a recognized complication (e.g., liver or kidney biopsy), or cross-match for units of packed red blood cells if greater risk of significant bleeding (e.g., angioplasty). Repeat type and screen is necessary after 3 days, or if blood products have been given in the interim. Blood products (e.g., FFP, platelets, cryoprecipitate) must be organized to be available if needed, and ideally only used if necessary, to avoid the potential for adverse reactions and disease transmission to the patient [11].

Biochemistry

- Electrolytes: In certain patients, assessment of the patient's electrolyte levels is indicated. For example, abnormal serum K^+, Ca^{2+}, and Mag^+ levels may need to be corrected to reduce the risk of wire-induced cardiac arrhythmia.

Table 2.8 Commonly used drugs (in alphabetical order)

Name	Dose
Acetaminophen	15 mg/kg PO
Adenosine	0.1 mg/kg/dose IV rapidly
Cefazolin	30 mg/kg/dose IV
Cefoxitin	30 mg/kg/dose IV
Diphenhydramine	1–2 mg/kg/dose IV (anaphylaxis)
Fentanyl	1 μg/kg/dose IV
Flumazenil	10 μg/kg IV over 15 s. Wait 1–3 min. Repeat up to four times
Glucagon	0.02–0.03 mg/kg/dose. Max dose 0.5 mg <20 kg; 1 mg > 20 kg
Heparin	50–100 units/kg to max 5,000 units loading dose
Ketamine	0.25 mg/kg/dose IV
Midazolam	0.05 mg/kg/dose IV; 0.5 mg/kg/dose PO <20 kg; 0.3 mg/kg/dose >20 kg
Morphine	0.05 mg/kg IV dose
Naloxone	0.001–0.01 mg/kg/dose for narcotic reversal in sedated patients
Sucrose	23–32 weeks: up to 0.5 mL PO 2 min prior to procedure
	32–37 weeks: up to 1 mL PO 2 min prior to procedure
	>37 weeks: up to 2 mL PO 2 min prior to procedure
	All infants who are NPO: up to 0.5 mL PO 2 min prior to procedure. Dose may be administered in increments of 2-min intervals for prolonged procedures; divided or repeated to the maximum daily dose. Maximum daily dose: four times in 24 h
Topical anesthetic	Lidocaine (Maxilene) topical anesthetic cream: 2 %—thin layer to skin
	Tetracaine (Ametop) 4 % cream/patch—thin layer to skin

- Creatinine: The creatinine level is important prior to the use of large volumes of iodinated contrast (Table 2.3).

Other

For invasive procedures in patients with complex conditions (e.g., hemophilia or diabetes mellitus), blood work is usually managed in cooperation with the referring teams to determine adequate coagulation factor levels, serum glucose, fibrinogen, etc.

Table 2.9 IV Fluid maintenance and bolus guidelines

Maintenance		
Weight	Daily volume	Hourly volume
1–10 kg	100 mL/kg/day	4 mL/kg/h
11–20 kg	50 mL/kg/day	2 mL/kg/h
>20 kg	20 mL/kg/day	1 mL/kg/h
Bolus		
Hypovolemic shock	20 mL/kg bolus, repeat prn	Give rapidly over 5–10 min
Cardiogenic shock	5–10 mL/kg bolus, repeat prn	Give slowly over 10–20 min

Examples:
Maintenance 23 kg child daily: 1000 mL + 500 mL + 60 mL = 1560 mL/day (~65 mL/h)
Maintenance 23 kg child hourly: 40 mL + 20 mL + 3 mL = 63 mL/h (~1512 mL/day)

Medications

Review of the patient's medications is important to ensure that specific medications are discontinued (e.g., antiplatelet agents for 5 days prior to the procedure, anticoagulants for required time interval, etc.) [9]. Parents will need advice regarding continuation of vital oral medications to be taken the morning of the procedure with the minimal amount of water possible (e.g., antiseizure medications). Preparatory medications must be planned, e.g., bowel-cleansing agents (Pico-Salax, Ferring Inc., North York, Ontario, Canada) and clear fluid diet for 48 h pre-cecostomy tube insertion, steroid premedication for radiographic contrast allergy, and timing of tetracycline pre-bone biopsy for bone histomorphometry in osteoporosis [12–14].

"One-Stop Shopping"

In the pediatric population, it is worthwhile from the perspectives of resource utilization and patient safety and convenience to plan for several procedures under one sedation. This needs to be addressed during the work-up period and takes foresight and effort to coordinate. It is important to ensure that all the planned procedures are compatible together and that the order of procedures is optimal, i.e., that the performance of one does not prevent or interfere with the next procedure (e.g., a US-guided abdominal procedure should precede introduction of intraperitoneal gas during a laparoscopic procedure).

Table 2.10 Sodium recommended in routine post-procedure fluids

Fluid	Na^+ mmol/L	K^+ mmol/L	Dextrose g/100 mL	Tonicity
D5W (dextrose 5 % in water)	0	0	5	Hypotonic
D10W (dextrose 10 % in water)	0	0	10	Hypotonic
NS (normal saline, 0.9 % NaCl)	154	0	0	Isotonic
½ NS (half normal saline, 0.45 % NaCl)	77	0	0	Half-isotonic
$\frac{2}{3}:\frac{1}{3}\left(\frac{2}{3}\text{ dextrose and }\frac{1}{3}\text{ saline}\right)$	45	0	3.33	Hypotonic
Ringers lactate	130	4	0	Isotonic

Informed Consent

Informed consent before an interventional case is a significant part of any IR practice, but especially so in pediatrics. The consent process may take longer and be significantly more detailed than adults. It is usually obtained from a substitute decision maker (SDM) such as a parent or guardian. Obtaining adequate and appropriate consent is truly a process rather than a single event or a form-filling exercise [15, 16]. Adequate time spent on the consent process, in addition to being an ethical imperative, is invaluable in increasing compliance with the preparation, procedure, and follow-up, in patient and family satisfaction, and in establishing rapport prior to the case in the event of complication. Sometimes the parents need to meet on more than one occasion, in order to fully accept their child's condition and understand treatment options. They should meet a member of the team in the IR clinic or during an assessment on the ward, and have the opportunity to ask their relevant questions and consider all the options, before signing consent. Parents are frequently too stressed immediately before a procedure to comprehend a detailed explanation of a procedure and its risks. Ideally therefore, when time permits, informed consent should be obtained in advance of the procedure in a separate encounter with the parents, even if separated by a few hours or the day before, rather than immediately prior to the patient entering the IR suite. Sitting with them, explaining in understandable terms, and providing diagrams and written material in advance of the procedure time are all strategies to ensure a SDM has the best opportunity to absorb the content fully which in turn supports informed decision making [17–19]. At the time of the procedure, they may wish to revisit some issues previously discussed, to refresh or clarify their understanding.

The responsibility of the interventionalist is to outline material risk [15]: those risks that are common but may be minor (e.g., site problems with a gastrostomy tube), those that are rare but severe (e.g., death), as well as the recognized risks in the range between that the average person would wish to know (e.g., central venous catheter-related thrombosis, infection). It is also important when possible to involve the pediatric patient in the discussion to the extent that is appropriate for their age, obtain a verbal assent, and address the child's worries or concerns [20]. It is necessary to document the risks that were discussed. A signed written consent must be obtained from the SDM and placed in the medical record.

Atypical Situations for Consent

In difficult clinical/psychosocial situations, where it is not clear what the proper or advisable course of action is, it may be helpful to contact the Bioethics Department or even the Risk Management Department for advice:

Age. In some jurisdictions there is no lower limit of age for consent, and the concept of maturity has replaced chronological age [15]. In these jurisdictions, as long as the patient has an understanding of the procedure, its implications, and the alternatives, they may sign. Some older teenagers prefer to sign their own consent, which is legally valid in some jurisdictions. In other jurisdictions, the patient must be over 18 years to sign. In common practice, however, most parents or guardians provide written consent, even for teenage patients [20–22].

Legal status. In pediatrics, obtaining consent through SDM (parents and guardians) may pose specific additional ethical/legal difficulties. It is important to clarify that the person giving consent is in fact the legal guardian (e.g., in blended families, grandparents with signing authority). Procedures planned for children who are in the care of child protection services require that the consent is obtained through their case worker. Informing and involving the biological parent is, however, usually appropriate, even if they do not actually sign the consent.

Cultures. In certain families, the parent may dictate that the child is not informed or given minimal information about the procedure. This may prove stressful for the physician obtaining the consent. A balance needs to be achieved between the child's right to know and the parent's opinions.

Religious. Religious beliefs may influence consent, especially with respect to giving of blood products or DNR status. In most institutions, legally approved consent forms are available that have been approved by representatives or religious elders of the group, such as Jehovah's Witness.

Telephone. Consent may have to be obtained over the telephone if person-to-person consent is not possible. This is not uncommon in the case of a newborn where the mother is at an obstetric facility or parents are at home looking after siblings. Distance adds an emotional strain for the parents when giving consent. It is good practice, and in many facilities required, that a witness (another health-care professional such as a nurse or IR team member) cosign the consent form with the interventionalist, attesting that the person has understood what has been explained and that they give approval to proceed.

Emergency. In cases of emergency without parents present, the referring physician or two physicians in some jurisdictions may give consent. He or she must document and sign to that effect in the medical records [22].

Off-label. Parents must be informed of any use of devices or drugs that are not approved, special access, or "off label," e.g., intrasalivary injections of Botox for drooling in children with cerebral palsy [23].

Alterations. Some parents may wish to change part of the institution's consent form, e.g., dictate that no fellow be involved in the procedure. In academic institutions, this can be challenging. It is usually not advisable that the form be altered and it is prudent to seek advice from the Risk Management Team or the hospital's lawyers in such situations.

Information Pamphlets

Information pamphlets, which provide parents with simple, direct, clear facts either in paper or online format, are valuable resources in terms of increasing access to information and providing consistent information. Parents usually welcome as much information as possible and appreciate the ability to review it at their own pace. Diagrams and sketches are helpful to explain many concepts or procedures.

Fasting Status

The guidelines for fasting vary slightly from institution to institution and it is important to operate within them. In general, the guidelines for sedation are similar to those for general anesthetic. Although fasting from midnight may be suitable for adults undergoing an anesthetic, this is inappropriately long for most young children. Prolonged fasting for solids or liquids may result in dehydration and/or hypoglycemia. A commonly used and simple to remember recommendation is the "2, 4, 6, 8 rule" (Table 2.4). Vital medications (e.g., antiseizure) may be given with a small amount of water.

Clinical Care During Procedure

Sedation and anesthesia are dealt with in Chap. 3. Specific aspects of clinical care pertinent to each different procedure type are also addressed in detail in individual chapters. This section deals with the more general principles/aspects of clinical care during a procedure.

Even for the most minor of cases (e.g., gastrostomy tube change), it is imperative that the room is equipped with suction, oxygen, and masks for bag-mask ventilation and that these are checked, available, and functioning at the start of each day. Consideration should be given as to whether the parent will be in the room, distraction techniques (DVDs, etc.), and the need for a Child Life worker to be with the child. In the event of an adverse outcome during a procedure, there is increasing evidence to support that the parent or family member stay during the resuscitation [24]. It is often helpful for the family to be present. Parents of chronically ill children are usually comfortable with medical equipment and emergency procedures. It has generally been found not to be disruptive or stressful for the staff [24]. In the event of such an occurrence, there needs to be a person assigned to be with the parent, to explain, comfort, and support the family—and should the need arise to respectfully ask the family to leave if their presence is considered detrimental to the resuscitation.

Checklists and Time-Out

In recent years the use of safety measures including pre-procedure "huddles," checklists, time-outs, and others has become the norm prior to an invasive procedure [25–27]. The "huddle" is valuable prior to bringing a patient into the suite, to discuss patient-specific issues, review the plan for the procedure(s), ensure that all necessary equipment is available, including blood if necessary. It is also important to share with the team pre-procedure information such as the side of the table one plans to work at as it may influence room set up (e.g., a left-sided empyema for pleural drainage), the need for bladder catheterization, or the need for an NG tube.

At the time-out, personnel in the room ensure that all necessary aspects of the case/concerns are known, the correct patient is present, the correct procedure is going to be done, the correct site has been identified and marked, informed consent for all procedure(s) has been obtained, allergies are noted, need for pre-procedure prophylactic antibiotics is determined (noting that to be effective, prophylactic antibiotics must be given within 1 h of "knife/needle-to-skin"), pregnancy status determined (date of last menstrual period, pregnancy test result), the correct name is on the imaging monitors, radiation protection equipment is in place (e.g., table skirt), grid is in or out, and orientation of imaging is correct (e.g., when performing CT fluoroscopy, correct patient orientation is selected, prone or supine, head or feet first, and the working side of the table). All members of the team in the room should stop momentarily to listen and participate in the time-out. Any anticipated adverse events should be raised (e.g., known airway compromise, expected blood loss, possible bradycardia/asystole during mechanical thrombectomy) and the presence of the necessary equipment in the room is ensured (e.g., flexible bronchoscope, blood products, correct French size, and length of double J stent). Some centers insist on a team introduction during the time-out (see Table 2.5) [25].

Organs with laterality (e.g., kidney) or those with multiple options (e.g., joints in hands or feet) should be marked pre-procedure [27]. It is imperative to mark the correct sites before the child is sedated, with involvement and agreement of the parents. The marking should be with a safe skin marker and using the operators' initials rather than an "X" or "*."

At the end of the procedure, another "time-out" ensures that the correct specimens have been labeled and sent to the laboratory as required, allergic dressings are avoided, and all the requested procedures have been done before the child is awakened [25]. This is especially relevant in the "one-stop shopping model," to ensure that all the teams have attended. The team(s) must discuss post-procedure orders to ensure that there is no conflict between orders from different teams.

Monitoring

The level of monitoring during a case depends not just on the level of sedation or anesthesia but also on the invasiveness of the procedure. For example, a liver biopsy under local anesthetic, even without sedation, still carries the risk of significant bleeding and therefore monitoring and documentation of blood pressure and pulse is important during the procedure; drainage of a large volume of ascites requires monitoring of pulse, blood pressure, and respirations because of fluid shifts. Usually the minimum requirement is electronic heart tracing, continuous oxygen saturation measurements, pulse rate, and intermittent blood pressure records. These values must be interpreted within the norms for the child's age (6, 7) and within the trend for the individual patient. Temperature monitoring is especially important in the younger child, who can rapidly lose body heat. Hypothermia is defined as a core temperature <35 °C, and temperatures <36 °C should be avoided especially in the neonate [28]. Equipment requirements for such monitoring are discussed in Chap. 1. Documentation of monitoring during the procedure is imperative, in the form of an anesthetic record, sedation record, or another monitoring record for cases done under local anesthetic, such as PICC insertion or paracentesis. The record provides a pattern or trend of the child's vital signs for comparison in the recovery phase (Table 2.6).

Medications/Fluid Management Pre-, Per-, and Post-procedure

As pediatric patients come in all sizes and weights, medication dosages must be calculated according to patient weight. Some drugs frequently used in PIR are shown in Table 2.8. With respect to intravenous fluids, consideration must be given to fluid regimens (Tables 2.9 and 2.10). There are standard maintenance fluid regimens calculated according to patients' weights (Table 2.9). These are suitable for the majority of children. However, in specific groups of children, these may be harmful, in volume and/or constituents. Some of these clinical situations will be beyond the expertise of many pediatric interventionalists; it is incumbent on the IR team to seek advice from those most expert in that specific fluid management. Examples of such circumstances are shown:

- Renal impairment—fluid restriction, impaired potassium, and sodium balance: the advised fluid management should be discussed with the referring or attending nephrologists.
- Cardiac disease—unable to tolerate routine fluid maintenance volumes without causing cardiac decompensation: fluids should be given cautiously and ideally with advice from cardiologists.
- Metabolic disorders—unique needs for chemical composition and volume requirements pre- and post-procedure, e.g., avoidance of hypoglycemia in glycogen storage disorder type 1. These become especially challenging if fasting is expected to extend post-procedure, e.g., post-gastrostomy tube insertion.
- Diabetes mellitus—usually successfully managed by the consulting endocrinology service who manages their insulin and IV fluids.
- Diabetes insipidus—has large fluid and sodium requirements, should be the first case of the day, should have their urine output monitored during the procedure (if necessary via bladder catheter), and should have care taken to avoid hypovolemia and serious sodium shifts.
- Ketogenic diet for intractable seizures—is maintained within a tight range of ketosis and requires avoidance of sugar in most situations.
- Hemoglobinuria—double fluid maintenance is usually required.

In addition to general considerations of fluid volumes, there is concern with respect to the amount of sodium recommended in routine post-procedure fluids. Traditionally a glucose-containing solution with little salt (hypotonic) was employed in the past, e.g., Dextrose 5 % and 2/3:1/3—hypotonic fluids (see Table 2.10) [29]. However, cases of severe iatrogenic hyponatremia with resulting morbidity and mortality have been reported in hospitalized children, especially in the post-procedure period [30]. With recognition of the adverse effects of hyponatremia in children, a salt-containing isotonic solution during the periprocedural period is now recommended in pediatrics to avoid the effects of low sodium [31]. Use of glucagon during IR procedures can lead to transient rise in blood sugar followed by a rebound hypoglycemia. Therefore, IV fluid maintenance with a glucose-containing solution is important and checking serum glucose may be necessary post-glucagon [32].

Volume of iodinated contrast given is important especially in the young child. Although 3 mL/kg. is considered the conservative limit in diagnostic imaging procedures, this can be exceeded to approximately 6 mL/kg. when spread over the period of time during an IR procedure, e.g., angiography [33]. Careful recording of the volume of contrast administered throughout the entire procedure is necessary, both in terms of hand and pump injections. Use of dilute contrast (50:50) will frequently be adequate for visualization and results in less contrast load. The recorder, either the nurse or the technologist in the room, should alert the operator intermittently to the total contrast volume used. Use of small volume syringes (e.g., 3 cm^3) to draw up the contrast helps avoid inadvertent administration of excessive amounts in small children and minimizes wastage.

Radiation Protection

The topic of radiation protection can be approached from a departmental perspective of optimum equipment, applications, and safety devices (Chap. 1), as well as from an individual patient/procedure perspective, including patient and occupational dose [34, 35]. The responsibility for radiation protection at the individual level is a shared one resting to a major degree with the interventional radiologist and the technologist. Radiation awareness is the most important first step—awareness about dose for the patient and scatter radiation for the whole team. Whenever possible, imaging modalities that do not involve radiation should be employed, but when X-ray imaging is required, there is a responsibility to use all available radiation protection options and strategies especially in pediatric patients and personal protective devices for the team (Table 2.11). The following are some of the steps the individual provider should consider during a procedure [36].

Fluoroscopy

Keeping the "beam on time" to a minimum is the operator's most effective method to reduce patient dose—stepping as infrequently and briefly as possible on the fluoroscopy pedal, as the Image Gentle "Step Lightly" Initiative advocates [37]. Choosing the lowest pulse rate available which enables the procedure to be completed

Table 2.11 Abbreviated and modified from the Image Gently "Step Lightly" checklist*

	Patient protection	Personnel protection
General	Awareness of patient radiation history	Vigilant about personal fitted lead aprons, thyroid, glasses
US vs. X-ray	Use ultrasound, if possible	
DSA	Plan each run carefully	Use pump injection > hand injection if possible
	Avoid improper runs	Maximize distance from primary beam
	Min # frames/s	Use table skirt and hanging shields
	Short a run as possible	
	Minimize overlapping fields	
Fluoroscopy	Set pulse rate as low as possible	Use table skirt and hanging shields
	Minimize time with foot on pedal	Keep hands out of primary beam
	Review and use image saves	when using X-ray (fluoroscopy)
	Keep magnification to a minimum	Angle away from hands
	Use post-processing zoom	Heed alerts re-fluoroscopy time
	Collimate, without fluoroscopy if possible, excluding radiosensitive organs	

Occupational dose is related to patient dose. Steps to reduce patient dose also reduce occupational dose
* *Source*: www.imagegently.org
With permission: The Alliance for Radiation Safety in Pediatric Imaging

(e.g., 3 pulses/s) should be used. Optimum imaging is not always required for many procedures (e.g., gastrostomy tube change), where the "good enough" concept is more applicable. Smoothing of the image on current generation equipment enables a very low pulse rate to be used without a visible staccato effect. In equipment that has a removable grid, it is important to remove or insert the grid as one switches from a small to a large child. Use of collimation limits exposure to organs outside of the region of interest and can dramatically reduce the patient's effective dose. Newer equipment allows positioning without fluoroscopy and collimating on a last image hold—both excellent ways to reduce patient dose. Even without state-of-the-art equipment, careful manual positioning, avoidance of panning in search of the correct area, and collimation that is continuously adjusted as the procedure progresses, all assist in keeping patient dose to as low as reasonably achievable, ALARA [34–37]. Judicious use of magnification when needed, remembering to switch back down in magnification when not necessary, and +/− use of post-processing zoom are important factors in minimizing dose. The technologists play a major role in promoting dose reduction by taking the necessary steps to protect the patient and the team, alerting the operator who is otherwise absorbed and focused on the procedure about magnification and fluoroscopy time [34, 36]. A useful checklist is available on the Image Gently—Step Lightly web site for use (see Table 2.10) [37–39]. Ultimately, reducing radiation dose comes down to careful practice habits.

Exposures

Single spot exposures or angiographic runs are used if detailed image acquisition is required. Careful planning before a run is imperative to ensure that the position is correct, collimation is appropriately tight, magnification is as low as needed, frame rate is suitably adjusted to the rate of flow (venous or arterial), and contrast volume and pump settings are chosen properly. These will avoid aborted runs or the need to repeat a run [33, 36]. Newer equipment permits archiving of fluoroscopy runs, which may be of adequate quality to avoid the need for DSA in some circumstances. There is evidence that, for complex lesions, the use of rotational angiography results in dose savings, compared with repeated imaging in different projections [40, 41]. An additional clinical advantage of biplane imaging or rotational angiography in the pediatric setting is the need for less contrast. If and when CT is required, use of low-dose protocols is imperative, with significant gains possible by the adjustment of parameters including mA, KVp, number slices, and area covered [42, 43].

Occupational Dose

As occupational dose is largely influenced by the scatter dose from the patient, practices aimed at reducing patient dose also reduces scatter radiation to the team [36, 44]. Availability and use of personal protective devices is obligatory (see Chap. 1). In addition to the use of protective devices, careful personal practices and behaviors influence occupational dose for the individual and the whole team. Use of the inverse square law for distance from the source is a powerful tool to reduce dose to personnel. Approximation of the image intensifier or flat plate detector to the patient is another example of a technique to reduce occupational dose.

Supplies

For certain conditions, the creation of specific supply "kits" can be a very practical and helpful aid in the clinical management of the patient. Although there is a trend toward creating completely latex-free environments in pediatric facilities, it is helpful to have a "latex-free box" which can be brought in for a patient who is latex allergic; all contents are latex-free, so there is no doubt as to the whether certain dressings or devices contain latex or not [45]. In another example, children with epidermolysis bullosa are now living longer and therefore increasingly being referred for IR-type procedures (e.g., esophageal dilatation, gastrostomy placement, and venous access devices). The creation of an “epidermolysis bullosa box” contains all the appropriate types of dressings that are suitable for their skin [46].

Communication and Hand-Off

At the end of the procedure, a note must be written in the chart and an appropriate IR team member speaks to the parents. Necessary precautions for post-procedure recovery are reviewed with the recovery team and floor nursing staff (e.g., patient positioning, serum glucose level checks, etc.). Post-procedure orders are written to communicate issues of monitoring, fluid intake (oral or IV), antibiotics, time for discharge, etc. A phone call to the referring physician is clinically worthwhile and promotes good clinical relations. A radiology report is dictated as soon as possible.

Post-procedure Care

During the immediate post-procedure phase, nursing care involves patient monitoring during recovery from the effects of sedation, anesthesia, and the procedure, as requested in the post-procedure orders—vital signs (pulse, blood pressure, respiratory rate, temperature, pain score) and urine output (see Tables 2.1, 2.6, and 2.7). Later a member of the IR team should review the patient for his/her general well-being. In addition the procedural site is examined and signs of procedure-specific complications should be sought (e.g., swelling/bleeding at port insertion site; pallor, coolness, presence of pedal pulses post-angiography; macroscopic hematuria post-renal biopsy; hemoglobinuria post-thrombectomy). A written note of the visit should be made in the chart, dated, timed, and signed. If the patient is well, the IR team may sign off or choose to follow with subsequent visits. If the patient is due to go home, discharge information for the family is required (see below).

In the event of a complication or concern, the IR team takes the appropriate measures, relevant orders are placed, and the patient remains on the list for further follow-up. The IR team may need to consult other specialties to assist in the management of a complication (e.g., general surgery in case of a bowel perforation, plastic surgery in the event of skin ischemia/ulceration). The IR team should assume this responsibility and directly liaise with the other specialists as needed.

Follow-Up

The state-of-the-art interventionalist is a clinician who follows his or her patients outside of the IR suite. Either the interventionalist or an appropriate member of the IR team (e.g., physician extender) should review the patient post-procedure [2, 47, 48]. Whether this is driven by desire to practice good medicine, institutional expectations, demands of clinical colleagues, billing, or local regulatory requirements, this development is a positive one. At minimum an inpatient should be seen on the ward later in the day of the procedure, and an outpatient should be seen before discharge. Further follow-up is necessary for some of the IR procedures (e.g., radiofrequency ablation of osteoid osteoma) as outlined in Chap. 1. The benefits of follow-up—including timely recognition of complications and appropriate longitudinal care—are also discussed in Chap. 1.

Early Follow-Up: Inpatient

In addition to the immediate ward visit following the procedure, subsequent single or ongoing daily post-procedure ward visits are indicated for certain groups of patients. They may include those with a possibility of a late/delayed complication (e.g., high-risk transjugular liver biopsy, peritonitis post-gastrostomy tube insertion, fluctuating hypertension post-renal angioplasty), as well as those who have a catheter or drain in situ following their IR procedure (e.g., post-empyema drainage). The latter patients should be followed until resolution of the problem (e.g., gastrostomy achieving full feeds) or removal of a device (e.g., chest drain removal post-empyema). The IR team should advise and plan for any subsequent measures required, such as the timing and type of repeat imaging, the use of tissue plasminogen activator (tPA), and the decision when to remove the drain. The IR team should remove the drain (e.g., transrectal drain on resolution of pelvic collection). Subsequent follow-up depends on the nature of the procedure. Service-type procedures such as image-guided percutaneous biopsies and placement of vascular access devices do not usually require further visits beyond the immediate post-procedure time. Some exceptions may apply, e.g., repeat packing of a wound following a port removal for purulent port pocket infection. Other cases require longer-term follow-up in an outpatient setting, to ensure they are not lost to follow-up (see below).

Informed Discharge

Informing patients and families about what to expect post-procedure, what signs and symptoms to look out for as indicators of a complication, and instructions regarding bathing, activity, and dressings can be done verbally but more appropriately should be with written discharge instructions, or information pamphlets, including names and telephone numbers of whom to contact in the event of a problem. The provision of informed discharge should be documented in the medical records. Some centers prefer to use an informed discharge form, which the parents sign, a copy of which is then placed in the medical record, to document that the parent/guardian has received the necessary instructions. The printed discharge information is also useful for any subsequent visits to the Emergency Department, as it documents the procedure and device (e.g., post-intrasalivary Botox injections for drooling; intramuscular Botox for spasticity; size and type of vascular access device) [49, 50].

Early Follow-Up: Outpatient

Many IR procedures are performed in the outpatient setting, which is efficient in terms of health-care resources and is emotionally and psychologically better for many children. Along with an outpatient IR service, or early discharge of inpatients, comes a responsibility to address aftercare and follow-up. Informed discharge is discussed above. For the outpatient, a follow-up phone call by a member of the IR team (e.g., clinic nurse) is one way to provide continuity of clinical care. It provides support for families and a means to answer their questions (e.g., management of PleurX catheters in malignant effusions). It also provides reassurance for the IR team regarding the procedure and the patient's well-being. For those procedures in which IR is providing a major component of treatment (e.g., radiofrequency ablation of a lesion), a return visit to the IR clinic ensures the patient is not lost to follow-up [2–4]. It provides the opportunity for assessment of treatment efficacy, any unexpected developments (e.g., purulent discharge/infection at site), and ongoing education (e.g., irrigation and bowel management post-cecostomy tube insertion). Some groups of procedures may be followed in a multidisciplinary clinic organized with another specialty (e.g., with plastic surgery for vascular anomalies, with urology for angiomyolipoma post-embolization) (see Chap. 1).

Late Follow-Up

For those in whom the IR treatment is the definitive therapy (e.g., varicocele embolization), arrangement for late follow-up is necessary. Depending on the procedure, this will vary both in timing (e.g., a few weeks following ablation of an osteoid osteoma, 3–6 months post-varicocele embolization) and in location (e.g., in the IR clinic or in a multidisciplinary clinic). The IR team is responsible to plan for and schedule follow-up procedures required for their devices (e.g., exchange of a long-term biliary or ureteric stent, removal of a transgastric pancreatic pseudocyst drain, and follow-up of a fistula). This is especially true for those devices that are only internal, with no external reminder for the patient or the physician that there is a device that warrants attention (e.g., IVC filter). The IR team is the health-care team most knowledgeable about the subsequent management required and has a responsibility to ensure the patient is not lost to follow-up.

Rather than considering the clinical roles outlined above as daunting for the interventional team, it can be embraced and incorporated into daily practice, as it is a significant step forward in providing excellent patient care.

References

1. American College of Radiology, The American Society of Interventional and Therapeutic Neuroradiology, The Society of Interventional Radiology. Practice guideline for interventional clinical practice. J Vasc Interv Radiol. 2005;16:149–55.
2. Baskin K, Hogan M, Sidhu M, et al. Developing a clinical pediatric interventional practice: a joint clinical practice guideline from the society if interventional radiology and the society for pediatric radiology. J Vasc Interv Radiol. 2011;22:1647–55.
3. American College of Radiology White Paper: Clinical Practice of Interventional Radiology and Neurointerventional Radiology White Paper. 2003. http//www.acr.org/dyna/?doc=departments/stand_accred/standards/ir_white_paper
4. Siskin GP, Bagla S, Sansivero GE, Mitchell NL. The interventional radiology clinic: key ingredients for success. J Vasc Interv Radiol. 2004;15(7):681–8.
5. Fontalvo LF, Amaral JG, Temple M, Chait PG, John P, Krishnamuthy G, Smith C, Connolly B. Percutaneous US-guided biopsies of peripheral pulmonary lesions in children. Pediatr Radiol. 2006; 36(6):491–7.
6. Daabiss M. American Society of Anaesthesiologists physical status classification. Indian J Anaesth. 2011; 55:111–5.
7. McCrone L, Alexander S, Karsli C, Taylor G, Amaral JG, Parra D, et al. US-guided percutaneous needle biopsy of anterior mediastinal masses in children. Pediatr Radiol. 2012;42(1):40–9. doi:10.1007/s00247-011-2204-2. Epub 2011 Aug 24.
8. Dipchand A, Jeremy Friedman J, editors. The Hospital for Sick Children. Handbook of pediatrics. 11th ed. Ed: Section III Laboratory References Values by Alabdulrazzaq, Adeli and Lau. W B Saunders Co Canada Ltd, Toronto. 1997;810–82.
9. Malloy PC, Grassi CJ, Kundu S, Gervais DA, Miller DL, Osnis RB, Postoak DW, Rajan DK, Sacks D, Schwartzberg MS, Zuckerman DA, Cardella JF, for the Standards of Practice Committee with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement. Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. J Vasc Interv Radiol. 2009;20:S240–9.
10. Firth PG, McMillan KN, Haberkern CM, Yaster M, Bender MA, Goodwin SR. A survey of perioperative management of sickle cell disease in North America. Paediatr Anaesth. 2011;21(1):43–9. doi:10.1111/j.1460-9592.2010.03415.x. Epub 2010 Sep 29.
11. Lavoie J. Blood transfusion risks and alternative strategies in pediatric patients. Paediatr Anaesth. 2011; 21(1):14–24.
12. Chait PG, Shlomovitz E, Connolly BL, Temple MJ, Restrepo R, Amaral JG, Muraca S, Richards HF, Ein SH. Percutaneous cecostomy: updates in technique and patient care. Radiology. 2003;227(1):246–50. Epub 2003 Feb 11.
13. Rauch F. Bone biopsy: indications and methods. Endocr Dev. 2009;16:49–57. Epub 2009 Jun 3.
14. Thomsen HS. European Society of Urogenital Radiology (ESUR) guidelines on the safe use of iodinated contrast media. Eur J Radiol. 2006;60(3): 307–13. Epub 2006 Sep 11.
15. Evans KG. Consent: a guide for Canadian physicians. 4th ed. Ottawa: The Canadian Medical Protective Association; 2006.
16. Temple-Doig L, Gordon M, Buckenham T, Roake J, Lewis D. Informed consent for vascular intervention. N Z Med J. 2005;118(1221):U1630.
17. Davies L. The consent process in interventional radiology: the role of specialist nurses. Clin Radiol. 2004;59:246–52.
18. Foglia MB. A quality improvement approach to improving informed consent practices in pediatric research. J Clin Ethics. 2009;20(4):343–52.
19. Braddock C. "Surgery is certainly one good option": quality and time-efficiency of informed decision-making in surgery. J Bone Joint Surg. 2008; 90:1830–8.
20. Canadian Paediatric Society. Treatment decisions regarding infants, children, and adolescents. http://www.cps.ca/english/statements/B/b04-01.htm
21. Bello BA. Dignity and informed consent in the treatment of mature minors. J Int Bioethique. 2010; 21(4):103–22, 164–5.
22. Committee on Pediatric Emergency Medicine and Committee on Bioethics. Policy statement—consent for emergency medical services for children and adolescents. Pediatrics 2011;128:427–33.
23. SIR Policy on Off-Label Use. http://www.sirweb.org/clinical/policy.shtml
24. Kleinman ME, Schexnayder SM, Samson RA, et al. Pediatric advanced life support: 2010 American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2010;122:S876–908.
25. Gawande A. The checklist manifesto: how to get things right. New York: Metropolitan Books; 2009.
26. Norton EK, Rangel SJ. Implementing a pediatric surgical safety checklist in the OR and beyond. AORN J. 2010;92(1):61–71.
27. Angle JF, Nemcek AA Jr, Cohen AM, et al, for the SIR Standards Division. Quality improvement guidelines for preventing wrong site, wrong procedure, and wrong person errors: application of the Joint Commission "Universal Protocol for Preventing

Wrong Site, Wrong Procedure, Wrong Person Surgery" to the practice of interventional radiology. J Vasc Interv Radiol. 2008;19:1145–51.
28. Laffan EE, McNamara PJ, Amaral J, Whyte H, L'Herault J, Temple M, John P, Connolly BL. Pediatr Radiol. 2009;39(8):781–90.
29. Moritz ML, Ayus JC. Review of interventional procedures in the very low birth-weight infant (<1.5 kg): complications, lessons learned and current practice. Prevention of hospital-acquired hyponatremia: a case for using isotonic saline. Pediatrics. 2003;111(2): 227–30.
30. Eulmesekian PG, Pérez A, Minces PG, Bohn D. Hospital-acquired hyponatremia in postoperative pediatric patients: prospective observational study. Pediatr Crit Care Med. 2010;11(4):479–83.
31. Moritz ML, Ayus JC. Intravenous fluid management for the acutely ill child. Curr Opin Pediatr. 2011; 23(2):186–93.
32. Bernhard N1, McAlpine K, Moineddin R, Connolly BL.Variations in blood glucose levels following gastrostomy tube insertion in a paediatric population. Pediatr Radiol. 2014 Feb 18. [Epub ahead of print].
33. Heran MK, Marshalleck F, Temple M, Grassi CJ, Connolly B, Towbin RB, Baskin KM, Dubois J, Hogan MJ, Kundu S, Miller DL, Roebuck DJ, Rose SC, Sacks D, Sidhu M, Wallace MJ, Zuckerman DA, Cardella JF, Society of Interventional Radiology Standards of Practice Committee, Society of Pediatric Radiology Interventional Radiology Committee. Joint quality improvement guidelines for pediatric arterial access and arteriography: from the societies of interventional radiology and pediatric radiology. Pediatr Radiol. 2010;40(2):237–50.
34. Strauss KJ, Kaste SC. The ALARA (as low as reasonably achievable) concept in pediatric interventional and fluoroscopic imaging: striving to keep radiation doses as low as possible during fluoroscopy of pediatric patients—a white paper executive summary. Pediatr Radiol. 2006;36 Suppl 2:110–2.
35. Strauss KJ. Interventional suite and equipment management: cradle to grave. Pediatr Radiol. 2006;36 Suppl 2:221–36.
36. Connolly B, Racadio J, Towbin R. Practice of ALARA in the pediatric interventional suite. Pediatr Radiol. 2006;36 Suppl 2:163–7.
37. www.imagegently.org
38. Sidhu M, Strauss K, Connolly B, et al. Radiation safety in pediatric interventional radiology. Tech Vasc Interv Radiol. 2010;13(4):205.
39. Sidhu M, Coley B, Goske M, et al. Image gently, *step lightly*: increasing radiation dose awareness in pediatric interventional radiology. Pediatr Radiol. 2009; 39(10):1135–8.
40. Wielands JY, et al. Effective dose analysis of three dimensional rotational angiography during catheter ablation procedures. Phys Med Biol. 2010;55(3): 563–79.
41. Bridcut RR, Murphy E, Workman A, Flynn P, Winder RJ. Patient dose from 3D rotational neurovascular studies. Br J Radiol. 2007;80(953):362–6.
42. Parra DA, Chan M, Krishnamurthy G, Spiegel L, Amaral JG, Temple MJ, John PR, Connolly BL. Use and accuracy of US guidance for image-guided injections of the temporomandibular joints in children with arthritis. Pediatr Radiol. 2010;40(9):1498–504.
43. Zhu X, Felice M, Johnson L, Sarmiento M, Cahill AM. Developing low-dose C-arm CT imaging for temporomandibular joint (TMJ) disorder in interventional radiology. Pediatr Radiol. 2011;41(4):476–82.
44. Dauer LT, Thornton RH, Solomon SB, St GJ. Unprotected operator eye lens doses in oncologic interventional radiology are clinically significant: estimation from patient kerma-area-product data. J Vasc Interv Radiol. 2010;21(12):1859–61.
45. Taylor JS, Erkek E. Latex allergy: diagnosis and management. Dermatol Ther. 2004;17(4):289–301.
46. Mavili E, Amaral J, Healey A, Karsli C, Pope E, Connolly B. Percutaneous interventional radiology procedures in patients with epidermolysis bullosa: modifications and challenges. AJR Am J Roentgenol. 2010;195(2):468–75.
47. Connolly B, Mahant S. The pediatric hospitalist and interventional radiologist: a model for clinical care in pediatric interventional radiology. J Vasc Interv Radiol. 2006;17(11 Pt 1):1733–8.
48. Rosenberg SM, Rosenthal DA, Rajan DK, Millward SF, Baum RA, Silberzweig JE, Tuite CM, Cardella JF. Position statement: the role of physician assistants in interventional radiology. American Academy of Physician Assistants. J Vasc Interv Radiol. 2009; 20(7 Suppl):S337–41.
49. Khan WU, Campisi P, Nadarajah S, Shakur YA, Khan N, Semenuk D, McCann C, Roske L, McConney-Ellis S, Joseph M, Parra D, Amaral J, John P, Temple M, Connolly B. Botulinum toxin A for treatment of sialorrhea in children: an effective, minimally invasive approach. Arch Otolaryngol Head Neck Surg. 2011; 137(4):339–44. Epub 2011 Jan 17.
50. Ellies M, Rohrbach-Volland S, Arglebe C, Wilken B, Laskawi R, Hanefeld F. Successful management of drooling with botulinum toxin A in neurologically disabled children. Neuropediatrics. 2002;33(6): 327–30.

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Pediatric Interventional Radiology
Handbook of Vascular and Non-Vascular Interventions
Temple, M.; Marshalleck, F.E. (Eds.)
2014, XIV, 418 p. 241 illus., 61 illus. in color., Softcover
ISBN: 978-1-4419-5855-6