Chapter 6
Pediatric Vascular Access Surgery

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General Perspective and Overview

The relative risks and complications increase proportionately according to the site, size, and type and complexity of the problem being addressed within the chest and in relation to the age of the patient and other comorbidities. This is principally related to the surgical accessibility, ability to correct the problem, functional reserve, technical ease, and the ability to achieve correction of the problem.

The main serious complications are **bleeding and infection,** which can be minimized by the adequate exposure, mobilization, technical care, and avoiding injury and hematoma formation. Infection is the main sequel of tissue injury and hematoma formation and may arise from preexisting infection or be newly acquired. This can lead to **catheter infection** and **systemic sepsis**. Although very rare in children, **multisystem failure** and **death** remain serious potential complications from vascular access surgery and systemic infection.

This chapter therefore attempts to draw together in one place the estimated overall frequencies of the complications associated with vascular access procedures based on information obtained from the literature and experience. Not all patients are at risk of the full range of listed complications. It must be individualized for each

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Important Note
It should be emphasized that the risks and frequencies that are given here *represent derived figures*. These *figures are best estimates of relative frequencies across most institutions*, not merely the highest-performing ones, and as such are often representative of a number of studies, which include different patients with differing comorbidities and different surgeons. In addition, the risks of complications in lower- or higher-risk patients may lie outside these estimated ranges, and individual clinical judgment is required as to the expected risks communicated to the patient and staff or for other purposes. The range of risks is also derived from experience and the literature; while risks outside this range may exist, certain risks may be reduced or absent due to variations of procedures or surgical approaches. It is recognized that different patients, practitioners, institutions, regions, and countries may vary in their requirements and recommendations.

patient and their disease process but represents a guide and summary of the attendant risks, complications, and consequences.

With these factors and facts in mind, the information given in this chapter must be appropriately and discernibly interpreted and used.

For complications related to other associated/additional surgery that may arise during vascular access surgery, see the relevant volume and chapter.

Central Venous Catheter Line Insertion

Description

General anesthesia is required with an ultrasound or image intensifier available to assist in direct venous access. The aim is to gain access to either the subclavian or internal jugular vein by direct puncture using a percutaneous Seldinger technique (guide wire, dilator, separable sheath, Silastic catheter). Once inserted into the vein, the sheath can be stripped away, leaving the venous catheter. Alternatively, an open approach can be used, although this is more traumatic to the vein and is generally reserved for situations where percutaneous access is difficult or inadvisable. The skin puncture rarely requires closure, and usually a waterproof dressing is all that is needed.

Anatomical Points

The position of the subclavian and internal jugular veins is relatively constant, although there is some minor variation, due to differences in anatomy between individuals and the hydration status of the patient. Dehydration decreases venous size

Table 6.1 Central venous line insertion estimated frequency of complications, risks, and consequences

Complications, risks, and consequences	Estimated frequency
Most significant/serious complications	
Infection (overall)	5–20 %
Wound	5–20 %
Within the catheter	5–20 %
Systemic sepsis	1–5 %
Bleeding/hematoma formation (wound)	1–5 %
Thrombosis – SVC thrombosis/internal jugular/cephalic vein	5–20 %
Migration/displacement of the catheter tube	1–5 %
Catheter failure (late; from whatever cause)	5–20 %
Radiation exposure (for the patient) (low level)[a]	>80 %
Rare significant/serious problems	
Pneumothorax	0.1–1 %
Cardiac arrhythmias (catheter irritation of endocardium)	0.1–1 %
Nerve injury (depending on positioning)	0.1–1 %
Cutaneous nerve, vagus X nerve damage, etc.	
Failure to perform catheter insertion (technical problems)	0.1–1 %
Catheter tip embolus	0.1–1 %
Hemothorax	<0.1 %
Air embolism	<0.1 %
Subclavian vein fistula	<0.1 %
Multisystem organ failure[a]	<0.1 %
Death[a]	<0.1 %
Less serious complications	
Bruising	5–20 %
Wound dehiscence (open surgery)[a]	1–5 %
Skin/fat necrosis	0.1–1 %
Residual pain/discomfort/neuralgia	1–5 %
Delayed wound healing (incl. ulceration)	1–5 %
Wound scarring (poor cosmesis)	1–5 %

[a]Dependent on underlying pathology, anatomy, surgical technique, preferences, and comorbidities

and can make access more difficult. Placing the patient slightly "head-down" is helpful in dilating the venous system of the head and neck facilitating easier entry of the initial needle and reducing risk of air embolism. The pleura lies behind the medial 1/3 of the clavicle on each side and is at risk of puncture and inducing a pneumothorax.

Perspective

See Table 6.1. The procedure is usually associated with a low complication rate and most are minor, such as bruising, difficulty gaining access to the vein, and minor superficial infection. Major complications are rare, but can occur, such as pneumothorax, which may require further hospitalization or insertion of an underwater-seal chest drain tube. Cardiac arrhythmias and bleeding

are risks during insertion. Immediate withdrawal of the catheter wire or tube several centimeters will usually settle the arrhythmia. Catheter thrombosis, cardiac arrhythmias, and migration of the catheter are also potentially serious as the catheter may require removal and later reinsertion. Percutaneous CVC lines invariably fail over time due to infection, mechanical problems, or thrombosis, and regular replacement may avert these issues as clinical complications. Failure to complete the procedure by the percutaneous method will not usually disallow its insertion, since the open approach can then usually be safely used. Bilateral attempts at central line insertion via the subclavian approach at the same operation are not advisable within 24 h, as there is a risk of inducing bilateral pneumothoraces. Use of the internal jugular approach is preferable after a failed subclavian approach.

Major Complications

The main severe acute complications are **pneumothorax, cardiac arrhythmias, air embolism,** and **hemothorax.** Later**, infection** of the catheter line can lead to **systemic sepsis** and even **multisystem organ failure**, which is the major cause of **mortality**, especially in immunocompromised patients and severely ill patients. **Removal of the central line** invariably follows infection. Air embolism and hemothorax are very rare but can be life threatening. **Catheter blockage or leakage** due to a variety of problems, usually later, may require removal and reinsertion or adjustment. **Catheter thrombosis** and **pulmonary embolism** can occur and may be serious. **Axillary, subclavian, internal jugular, or superior vena cava venous** thrombosis can cause severe swelling of the arm, neck, head, and chest. **Carotid artery puncture** is minimized by the use of ultrasound guidance. **Cardiac arrhythmias** are usually terminated by withdrawal of the guide wire from the heart chamber, usually the atrium affecting the sinoatrial node.

Consent and Risk Reduction

Main Points to Explain

- Discomfort
- Bruising and bleeding
- Infection
- Pneumothorax (rare)
- Cardiac arrhythmias (usually minor)
- Failure of insertion
- Catheter displacement/later failure
- Further surgery

Tunneled Internal Jugular Central Venous Catheter Line Insertion

Description

General anesthesia is used, with an ultrasound and image intensifier present to assist in insertion and checking position. The aim is to insert the catheter into the internal jugular vein percutaneously (or open) and to tunnel this subcutaneously to a convenient site in the anterior axilla, upper chest, or abdomen for exit and access. The line can be inserted percutaneously or via an open approach. If using the percutaneous route, ultrasound guidance may lower the complication rate. The patient should be placed head-down to avoid an air embolus and the head rotated toward the other side to give more access. When using the open approach, a cervical skin crease incision is placed over the carotid pulsation, 1-finger width above the clavicle. The SVC is secured above and below the venotomy site and the largest catheter for the vein size is inserted. A circumferential 6/0 Prolene suture closes the venotomy against the catheter. Some catheters have a small Dacron cuff, which is positioned under the skin, to fixate the catheter.

Anatomical Points

The position of the subclavian and internal jugular veins is relatively constant; however, there is some relative variation between individuals and the hydration status of the patient. Dehydration decreases venous size and can make access more difficult. The internal jugular vein can overlie or even be medial to the carotid artery in some patients, and ultrasound guidance may be of value. The pleura lies behind the medial 1/3 of the clavicle on each side and is at risk of puncture and inducing a pneumothorax. Great care with the tunneling is required to avoid possible damage to the breast bud in girls as subsequent hypoplasia or problems in growth may develop.

Perspective

See Table 6.2. The procedure is usually associated with a low complication rate and most are minor, such as bruising, difficulty gaining access to the vein, and minor superficial infection. Life-threatening complications are rare and less common by the open compared with the subclavian route. Major complications are rare, but can occur, such as pneumothorax, which may require further hospitalization or insertion of an underwater-seal chest drain tube. Air embolus is very rare, especially if the "head-down" patient position is used, which is also helpful in dilating the venous system of the head and neck facilitating easier entry of the initial needle. Cardiac

Table 6.2 Tunneled internal jugular line insertion estimated frequency of complications, risks, and consequences

Complications, risks, and consequences	Estimated frequency
Most significant/serious complications	
Infection (overall)	20–50 %
Wound	1–5 %
Related to the catheter	5–20 %
Systemic sepsis	1–5 %
Bruising	20–50 %
Extravasation or bleeding/hematoma formation	1–5 %
Thrombosis – SVC thrombosis/internal jugular/cephalic vein	1–5 %
Seroma/lymphocele/lymphatic leak	1–5 %
Failure to perform catheter insertion (technical problems)	1–5 %
(Depends on number of previous catheterizations in dialysis patients and use of U/S)	
Catheter failure (from whatever cause)	1–5 %
[Misdirection; occlusion; kinking; fracture/breakage; too long/short]	
Rare significant/serious problems	
Pneumothorax (rare with internal jugular cannulation)	0.1–1 %
Cather malposition	0.1–1 %
Cardiac arrhythmias (catheter irritation of endocardium)	0.1–1 %
Migration/displacement of the catheter tube	0.1–1 %
Vessel perforation and hemorrhage	<0.1 %
Hemothorax (rare with internal jugular cannulation)	<0.1 %
Laryngeal edema	<0.1 %
Cardiac perforation and tamponade	<0.1 %
Air embolism	<0.1 %
Nerve injury (depending on positioning)	<0.1 %
Cutaneous nerve, vagus X nerve damage, etc.	
Catheter tip embolus	<0.1 %
Breast bud growth problems	<0.1 %
Multisystem organ failure[a]	<0.1 %
Death[a]	<0.1 %
Less serious complications	
Wound dehiscence	1–5 %
Skin necrosis	0.1–1 %
Residual pain/discomfort/neuralgia	1–5 %
Delayed wound healing (incl. ulceration)	1–5 %
Wound scarring (poor cosmesis)	1–5 %
Failure of breast bud development	<0.1 %

[a]Dependent on underlying pathology, anatomy, surgical technique, preferences, and comorbidities

arrhythmias and bleeding are risks during insertion. Immediate withdrawal of the catheter wire or tube several centimeters will usually settle the arrhythmia. Catheter thrombosis, cardiac arrhythmias, and migration of the catheter are also potentially serious as the catheter may require removal and later reinsertion. Percutaneous CVC lines invariably fail over time due to infection, mechanical problems, or

thrombosis, and regular replacement may avert these issues as clinical complications. Failure to complete the procedure by the percutaneous method will not usually disallow its insertion, since the open approach can usually be then used. Bilateral attempts at central line insertion at the same operation are not advisable within 24 h, as there is a very small, but important, risk of inducing bilateral pneumothoraces. Use of the open internal jugular approach can then be used. Great care with the tunneling is required to avoid possible damage to the breast bud in girls as subsequent hypoplasia or problems in growth may develop. Migration of the catheter is rare as textured cuff is incorporated by the surrounding tissues and usually holds it in place.

Major Complications

The main severe acute complications are **pneumothorax, cardiac arrhythmias, air embolism,** and **hemothorax.** Later**, infection** of the catheter line can lead to **systemic sepsis** and even **multisystem organ failure**, which is the major cause of **mortality**, especially in immunocompromised patients and severely ill patients. **Removal of the central line** invariably follows infection. Air embolism and hemothorax are very rare but can be life threatening. **Catheter blockage or leakage** due to a variety of problems, usually later, may require removal and reinsertion or adjustment. **Catheter thrombosis** and **pulmonary embolism** can occur and may be serious. **Catheter migration** is rare. Rarely, **breast bud development problems** can occur if the catheter tubing is tunneled too close to the nipple in the female child. **Axillary, subclavian, internal jugular, or superior vena cava venous** thrombosis can cause severe swelling of the arm, neck, head, and chest. **Carotid artery puncture** is minimized by the use of ultrasound guidance. **Cardiac arrhythmias** are usually terminated by withdrawal of the guide wire from the heart chamber, usually the atrium affecting the sinoatrial node.

Consent and Risk Reduction

Main Points to Explain

- Discomfort
- Bruising and bleeding
- Infection
- Pneumothorax (rare)
- Cardiac arrhythmias (usually minor)
- Failure of insertion
- Catheter displacement/later failure
- Further surgery

Open/Percutaneous Venous Access Devices (Infusion-Port) Insertion

Description

Under general anesthesia, access to either the subclavian or internal jugular vein is obtained using an open or percutaneous approach. The aim is to gain access to the subclavian or internal jugular vein by direct puncture using a percutaneous Seldinger technique (guide wire, dilator, separable sheath, Silastic catheter). Once inserted into the vein, the sheath can be stripped away to leave the venous catheter. Alternatively, an open approach can be used, although this is more traumatic to the vein. For an open approach, a transverse cervical skin crease incision is placed over the carotid pulsation, at triangle between the sternoclavicular heads of the sternomastoid muscle, 1-finger breadth above the clavicle to allow room for pressure if a vascular problem develops. The SVC is secured above and below the venotomy site and the largest catheter for the vein size is inserted. A circumferential 6/0 Prolene suture closes the venotomy. A separate subcutaneous pocket is made for the port, attached to the Silastic catheter. The catheter is tunneled to reach the vein. The position of the catheter in the superior vena cava can then be checked using image intensification radiology. The skin is then closed to render the whole system subcutaneous.

Anatomical Points

The position of the subclavian and internal jugular veins is relatively constant; however, there is some relative variation, due to differences in the surrounding bony anatomy between individuals and the hydration status of the patient. Dehydration decreases venous size and can make access more difficult. Placing the patient slightly "head-down" is also helpful in dilating the venous system of the head and neck facilitating easier entry of the initial needle and reducing air embolism. The pleura lies behind the medial 1/3 of the clavicle on each side and is at risk of puncture and inducing a pneumothorax.

Perspective

See Table 6.3. The procedure is usually associated with a low complication rate and most are minor, such as bruising, difficulty gaining access to the vein, and minor superficial infection. Life-threatening complications are rare and less common than by the subclavian route. Major complications are rare, but can occur, such as pneumothorax, which may require further hospitalization or insertion of an underwater-seal chest drain tube. Air embolus is very rare, especially if the

Table 6.3 Open/percutaneous venous access devices (including infusion-port) insertion estimated frequency of complications, risks, and consequences

Complications, risks, and consequences	Estimated frequency
Most significant/serious complications	
Infection (overall)	20–50 %
Wound	1–5 %
Related to the catheter/port	5–20 %
Systemic sepsis	1–5 %
Bruising	20–50 %
Extravasation or bleeding/hematoma formation	1–5 %
Thrombosis – SVC thrombosis/internal jugular/cephalic vein	1–5 %
Seroma/lymphocele/lymphatic leak	1–5 %
Failure to perform catheter insertion (technical problems)	1–5 %
(Depends on number of previous catheterizations in dialysis patients and use of U/S)	
Catheter failure (later; from whatever cause)	1–5 %
[Misdirection; occlusion; kinking; fracture/breakage; too long/short]	
Port leakage, rotation, separation from tubing, and skin erosion	1–5 %
Rare significant/serious problems	
Pneumothorax (rare with internal jugular cannulation)	0.1–1 %
Cardiac arrhythmias (catheter irritation of endocardium)	0.1–1 %
Catheter malposition	0.1–1 %
Migration/displacement of the catheter tube	0.1–1 %
Rare as cuff holds it in place	
Hemothorax (rare with internal jugular cannulation)	<0.1 %
Nerve injury (depending on positioning)	<0.1 %
Cutaneous nerve, vagus X nerve damage, etc.	
Laryngeal edema	<0.1 %
Cardiac perforation and tamponade	<0.1 %
Catheter tip embolus	<0.1 %
Air embolism	<0.1 %
Vessel perforation and hemorrhage	<0.1 %
Breast bud growth problems	<0.1 %
Multisystem organ failure[a]	<0.1 %
Death[a]	<0.1 %
Less serious complications	
Wound dehiscence	1–5 %
Skin necrosis	0.1–1 %
Residual pain/discomfort/neuralgia	1–5 %
Delayed wound healing (incl. ulceration)	1–5 %
Wound scarring (poor cosmesis)	1–5 %
Failure of breast bud development	<0.1 %

[a]Dependent on underlying pathology, anatomy, surgical technique, preferences, and comorbidities

"head-down" patient position is used. Catheter thrombosis, cardiac arrhythmias, and migration of the catheter are also potentially serious as the catheter may require removal and later reinsertion. Cardiac arrhythmias and bleeding are risks during insertion. Immediate withdrawal of the catheter wire or tube several centimeters

will usually settle the arrhythmia. Catheter thrombosis, cardiac arrhythmias, and migration of the catheter are also potentially serious as the catheter may require removal and later reinsertion. Percutaneous CVC lines and ports invariably fail over time due to infection, mechanical problems, or thrombosis, and regular replacement may avert these issues as clinical complications. Failure to complete the procedure by the percutaneous method will not usually disallow its insertion, since the open approach can usually be then used. Bilateral attempts at central line insertion via the subclavian approach at the same operation are not advisable within 24 h, as there is a risk of inducing bilateral pneumothoraces. Use of the internal jugular approach is preferable after a failed subclavian approach. Pneumothorax risk is about 1 in 200 cannulations via the subcutaneous approach, less with the internal jugular vein route. Problems related to the port include infection, skin necrosis, erosion, rotation, and separation from the tubing. Port rotation can be minimized using careful 3-point fixation of the port and leakage usually prevented by the use of the correct (Huber) needle type. Great care with the tunneling is required to avoid possible damage to the breast bud in girls as subsequent hypoplasia or problems in growth may develop.

Major Complications

The main severe acute complications with catheter insertion are **pneumothorax, cardiac arrhythmias, air embolism,** and **hemothorax.** Later**, infection** of the catheter line can lead to **systemic sepsis** and even **multisystem organ failure**, which is the major cause of **mortality**, especially in immunocompromised patients and severely ill patients. **Removal of the central line** invariably follows infection. Air embolism and hemothorax are very rare but can be life threatening. **Catheter blockage or leakage** due to a variety of problems, usually later, may require removal and reinsertion or adjustment. **Catheter thrombosis** and **pulmonary embolism** can occur and may be serious. Rarely, **breast bud development problems** can occur if the catheter tubing is tunneled too close to the nipple in the female child. **Axillary, subclavian, internal jugular, or superior vena cava venous** thrombosis can cause severe swelling of the arm, neck, head, and chest. **Carotid artery puncture** is minimized by the use of ultrasound guidance. **Cardiac arrhythmias** are usually terminated by withdrawal of the guide wire from the heart chamber, usually the atrium affecting the sinoatrial node. Problems related to the port include **infection**, **skin necrosis**, **erosion**, rotation, and **separation** from the tubing. **Port rotation or leakage/extravasation** requires **further surgery** for adjustment or **port removal**. Rarely, **breast bud development problems** can occur if the catheter tubing is tunneled too close to the nipple in the female child.

Consent and Risk Reduction

Main Points to Explain

- Discomfort
- Bruising and bleeding
- Infection
- Pneumothorax (rare)
- Cardiac arrhythmias (usually minor)
- Failure of insertion
- Catheter/port displacement/failure
- Further surgery

Further Reading, References, and Resources

Central Venous Line Insertion

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