Management of Inadvertent Arterial Catheterisation Associated with Central Venous Access Procedures

A. Pikwer a,*, S. Acosta b, T. Kölbl b, M. Malina b, B. Sonesson b, J. Åkeson a

a Department of Anesthesiology and Intensive Care Medicine, Lund University, Malmö University Hospital, SE-205 02 Malmö, Sweden
b Vascular Centre, Lund University, Malmö University Hospital, SE-205 02 Malmö, Sweden

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Abstract

Objective: This study aims to describe the clinical management of inadvertent arterial catheterisation after attempted central venous catheterisation.

Methods: Patients referred for surgical or endovascular management for inadvertent arterial catheterisation during a 5-year period were identified from an endovascular database, providing prospective information on techniques and outcome. The corresponding patient records and radiographic reports were analysed retrospectively.

Results: Eleven inadvertent arterial (four common carotid, six subclavian and one femoral) catheterisations had been carried out in 10 patients. Risk factors were obesity (n = 2), short neck (n = 1) and emergency procedure (n = 4). All central venous access procedures but one had been made using external landmark techniques. The techniques used were stent-graft placement (n = 6), percutaneous suture device (n = 2), external compression after angiography (n = 1), balloon occlusion and open repair (n = 1) and open repair after failure of percutaneous suture device (n = 1). There were no procedure-related complications within a median follow-up period of 16 months.

Conclusions: Inadvertent arterial catheterisation during central venous cannulation is associated with obesity, emergency puncture and lack of ultrasonic guidance and should be suspected on retrograde/pulsatile catheter flow or local haematoma. If arterial catheterisation is recognised, the catheter should be left in place and the patient be referred for percutaneous/endovascular or surgical management.

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The use of central venous catheters is widespread to provide venous access, nutritional support or to manage perioperative fluids. Central venous access procedures are associated with inadvertent arterial puncture or catheterisation in up to 6% of patients when using external landmark techniques,1 with subsequent development of haemorrhage,2 pseudoaneurysm,3 arteriovenous fistulation,4 arterial dissection,5 neurological injury6,7 and severe3,8 or even lethal9,10 airway obstruction.
Use of ultrasound guidance for placement of central venous catheters is still infrequent despite higher success rate and fewer complications. Arterial injury due to inadvertent catheterisation can be managed with open surgical techniques, although minimally invasive techniques have emerged as treatment options using stent grafts, percutaneous closure devices and balloon tamponade. The uncontrolled removal of intra-arterial catheters followed by external compression (pull and pressure) is associated with high complication rates.

The purpose of this study was to identify potential risk factors for and clinical signs of inadvertent arterial catheterisation after attempted central venous catheterisation and to review our experience of minimally invasive clinical management.

Methods

The study design was approved by the Human Research Ethics Committee of the Medical Faculty at the Lund University and carried out at a Swedish tertiary referral centre with a catchment population of approximately 1.6 million inhabitants.

Prospective information on techniques, equipment and outcome from an endovascular database of a total of 1079 patients undergoing intervention for carotid (n = 114), subclavian (n = 35) or femoral (n = 930) artery disease or injury between 1 January 2003 and 29 February 2008 were obtained. Patients referred for surgical or endovascular management of inadvertent arterial catheterisation after central venous catheterisation were identified by analysis of conventional angiography and also by computed tomographic angiography in six patients.

Patient characteristics and information on the reason for central venous catheterisation, emergency or non-emergency procedure, site of catheterisation, type and size of catheter, detection and diagnosis of inadvertent arterial catheterisation and clinical management before referral were all obtained from patient charts and radiological reports. All angiograms of the initial procedure and all

<table>
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<th>Table 1 Demographic, technical and clinical characteristics of the ten patients of inadvertent arterial catheterization after attempted central venous cannulation found in the present study. All stent-grafts were placed from the common femoral artery.</th>
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<tbody>
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<td>Age (years)</td>
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<td><strong>Common carotid artery</strong></td>
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<td><strong>Subclavian artery</strong></td>
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<td><strong>Superficial femoral artery</strong></td>
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follow-up examinations were retrospectively evaluated by an endovascular specialist.

Results

Patients

The study comprised 11 inadvertent arterial catheterisations made in 10 patients (five females) with a median age of 69 (range 37–81) years. Two patients had a body mass index exceeding 40 kg m$^{-2}$, another patient had an unusually short neck and four catheters were inserted during emergency procedures (Table 1).

Catheterisations

Four catheters had been placed in the common carotid, six in the subclavian (bilateral catheters in one patient) and one in the superficial femoral artery.

Figure 1  a. Angiogram made via a 12 Fr catheter (arrow), inadvertently placed in the proximal right common carotid artery with the tip positioned in the aortic arch of a 37 year-old male patient. b. The central venous catheter, inadvertently placed in the carotid artery, replaced by a Perclose® suturing device, and arterial sutures applied to the puncture site. The sliding knot was tied with a knot pusher (black arrow). The guide wire was withdrawn after haemostasis had been confirmed. A transfemorally introduced angioplasty balloon catheter (white arrow) in its introducer sheath was kept at ready for inflation in case of haemorrhage. c. Completion angiogram showing no extravasation or stenosis.

Four catheters had been intended for haemodialysis, another four for rapid restitution of plasma volume in major trauma and the remaining three for total parental nutrition, cardiac pacing or measurement of central venous pressure. Depending on the type of catheter, their outer diameter varied from 5 to 16 Fr.

Five patients were catheterised under general and five under local anaesthesia. Ten catheterisations were made using external landmarks. Guidance by ultrasound was used in one patient for an intended subclavian access.

Excessive or pulsatile backflow through the catheter (six patients) or local haematoma (two patients) were reported within 4 days of inadvertent arterial catheterisation in seven patients. Partial paralysis of the arm due to subclavian pseudoaneurysm was found in another patient soon after withdrawal of the catheter 26 days after catheterisation. Subclinical inadvertent arterial catheterisation was detected by computed tomography or fluoroscopy in the remaining three catheterisations made in two patients.
Of 11 catheters, 10 were left in the intra-arterial position on referral for surgical or endovascular intervention (Table 1).

**Common carotid injury**

All four interventions were made under general anaesthesia. Two injuries were successfully repaired with stent grafts. A self-expanding Fluency\textsuperscript{®} stent graft (Bard Peripheral Vascular, Inc., Tempe, AZ, USA) was used in a distal part of the vessel in the first patient and a balloon-expanded Jomed Stentgraft\textsuperscript{TM} (Abbott Laboratories, Abbott Park, IL, USA) was used in a lesion close to the brachiocephalic trunk in the second patient.

Perclose\textsuperscript{®} percutaneous suture device (Abbott Laboratories) was successfully used in the third patient with a 12 Fr dialysis catheter introduced in the middle portion of the vessel (Fig. 1a–c).

In the fourth patient, the catheter was safely withdrawn under manual compression after vascular access for angiographic mapping and instant management of haemorrhage (Table 1).

**Subclavian injury**

Two patients underwent arterial repair with stent graft or Perclose\textsuperscript{®} device under local anaesthesia, whereas the remaining four patients were treated under general anaesthesia. Four injuries were repaired with stent grafts.

Bilateral arterial catheterisations in a 77-year-old female patient with major trauma were revealed en passant by CT after emergency resuscitation. The left injury was successfully excluded with a balloon-expanded Advanta\textsuperscript{TM} V12 stent graft (Atrium Medical Corp., Hudson, NH, USA). A Perclose\textsuperscript{®} percutaneous suture device failed to seal the right subclavian artery injury. A Fluency\textsuperscript{®} stent graft was then placed but required further extension with another Fluency\textsuperscript{®} stent graft due to continued extravasation (Fig. 2a–c).

![Figure 2](url)

**Figure 2** a. Angiogram showing inadvertent bilateral catheterisations of the subclavian arteries with 7 Fr catheters intended for central venous catheterisation in a 77 year-old female with major trauma. Black and white arrows indicate vascular sites of catheter entry. b. Angiogram showing continuous extravasation (arrow) despite an 8 × 40 mm Fluency\textsuperscript{®} stent graft introduced transfemorally into the right subclavian artery. c. Angiogram showing no extravasation after a second 8 × 60 mm Fluency\textsuperscript{®} has been positioned as an extension to seal the subclavian vessel wall.
A 16 Fr catheter injury involving the origin of the right thyrocervical trunk in a 61-year-old female patient was managed by coil embolisation of its major branches followed by placement of a self-expanding Gore Viabahn® stent graft (WL Gore & Associates, Inc., Flagstaff, AZ, USA). Because of continuous extravasation after placement of the stent graft, caused by backbleeding, the thyrocervical trunk was further embolised with N-butyl cyanoacrylate (Histoacryl; Braun, Melsungen, Germany) mixed with iodised oil (Lipiodol; Laboratoire Guerbet, Roissy, France) and haemostasis was achieved (Fig. 3a–f, Table 1).

An obese patient (body mass index 58) with a 10 Fr haemodialysis catheter in the left subclavian artery was treated with two Fluency® Plus stent grafts.

One subclavian injury was successfully treated with a Perclose® percutaneous suture device.

The remaining injury, close to the origin of the right vertebral artery, was managed by a combined surgical and endovascular procedure. A balloon catheter was first inserted transfemorally and inflated at the puncture site while the artery was exposed and repaired by open arteriorrhaphy (Table 1).

**Superficial femoral injury**

A Prostar® percutaneous suture device (Abbott Laboratories) was used in a failed attempt to close the vascular injury in a uraemic, obese patient with an 11 Fr haemodialysis catheter placed in the right superficial femoral artery. Open surgical repair was then made by arteriorrhaphy under general anaesthesia (Table 1).

**Clinical follow-up**

One patient with major trauma died within 24 h, corresponding to 9% in-hospital mortality. Another patient with pseudoaneurysm and compression of the brachial nerve plexus had partial paralysis of the right arm at the time of diagnosis with little improvement at 20 months’ follow-up after hybrid surgery. No other patient had clinical signs of local complications. The median in-hospital stay was 2 (range 1–11) days without procedure-related complications and the surviving patients were followed up for 16 (2–50) months.

**Radiographic follow-up**

Patients were not routinely followed by vascular imaging techniques, but two patients were evaluated by radiography at the site of repair for other reasons.

An altered position without stenosis or fracture of a Jomed Stentgraft™ in the right common carotid artery was confirmed by CT angiography after 44 months in a 71-year-old female patient (Fig. 4). No signs for stenosis were detected by CT angiography 50 months after repair of the subclavian artery with a Perclose® percutaneous suture device in a 69-year-old male patient.

**Discussion**

Accidental arterial puncture may follow one out of 20 central venous catheterisation attempts.17 Because this complication is often recognised before the catheter is introduced into the blood vessel, inadvertent arterial catheterisation is much less common. In agreement with our findings, obesity,19 short neck19 and urgent catheterisation19 have been proposed to be risk factors for complications in central venous catheterisation. The hypovolaemic state, calling for immediate action, might have rendered accidental arterial puncture more likely and more difficult to detect, due to less pulsatile backflow of less oxygenated blood in our three patients with major trauma. Patients with hypotension and/or low haemoglobin saturation should thus be considered at particular risk for inadvertent arterial catheterisation.

Current clinical guidelines20 state that guidance by ultrasound, applied in one of 11 central venous catheterisations in the present study, reduces the risk of arterial puncture during central venous catheterisation. This has been convincingly shown for the internal jugular route,18,21 in agreement with reported inter-individual variation of the anatomical relationship between the internal jugular vein and the common carotid artery,19,22,23 but less so for the subclavian approach.18,21

Accidental arterial catheterisation should be suspected immediately on excessive or pulsatile backflow of well-oxygenated blood through the catheter or local haematoma at the site of catheterisation. Delayed diagnosis increases the risk of serious complications.11,14,24 An intra-arterial catheter position is confirmed by CT angiography or by angiography through the inadvertently inserted catheter.

Treatment strategies after inadvertent arterial catheterisation include local compression, open surgical treatment with direct arterial repair and percutaneous/endovascular treatment. Withdrawal of an arterial catheter may result in considerable haemorrhage,25 stroke26 or, as in one of our patients, pseudoaneurysm.27 Factors that are associated with an increased risk for serious complications after catheter removal are catheter diameter, time since catheter insertion and the puncture site. Open surgical treatment has been shown to be safe but can add significant morbidity as patients are often seriously ill and open repair can be complex, requiring general anaesthesia and perhaps sternotomy. Less invasive percutaneous or endovascular treatment of inadvertent catheterisation of the carotid, subclavian or femoral artery can even be performed under local anaesthesia. A number of recent case reports and small case series have drawn attention to these options of treatment with percutaneous closure devices or stent grafts.28,29 We report on 11 inadvertent arterial injuries in 10 patients and support the findings that endovascular management is feasible and safe.

The percutaneous suture device (Perclose®) technique has an almost 99% success rate for repair of the femoral artery after catheterisation with 12–16 Fr catheters and less than 2% late complications.30 As indicated by the present and previous31 findings, obesity is a risk factor for failure in achieving haemostasis with this technique. Failure of the technique after right subclavian catheterisation in the present study might have been caused by severe angulation of the device at the site of insertion. However, percutaneous closure devices have been reported to be successful in subclavian injury as well.13,32,33
Figure 3  a. In a 61 year old female a 16 Fr double-lumen catheter (arrow) was inadvertently inserted into the subclavian artery, and thereafter another 16 Fr double-lumen catheter was correctly positioned in the internal jugular vein. b. Posterior–anterior three-dimensional reconstruction of computed tomographic angiography showing the 16 Fr double-lumen catheter inadvertently passing caudally to the right clavicle into the right subclavian artery. The arrow indicates the vascular site of catheter entry at the branching of the thyreocervical trunk from the right subclavian artery. c. Angiogram made before withdrawal of the 16 Fr catheter inadvertently placed in the right subclavian artery. An 8 × 50 mm Gore Viabahn® stent graft (white arrows) was placed across the puncture site distally to the right vertebral artery, catheterised separately to secure access in case of overstenting. A 0.018-inch guide-wire passing through the inadvertently placed 16 Fr catheter proved to be most useful after withdrawal of the catheter (d and e). The thyreocervical trunk was embolized with metallic coils (black arrow) to prevent retrograde bleeding. d. Angiogram after withdrawal of a catheter inadvertently placed in the right subclavian artery showing continuous extravasation along the 0.018-inch safety guide partially withdrawn into the subcutaneous channel. e. Completion angiogram showing no further extravasation after embolization with N-butyl cyano-acrylate (Histoacryl; Braun, Melsungen, Germany) mixed with iodised oil (Lipiodol; Laboratoire Guerbet, Roissy, France). The arrow points at the glue in the subcutaneous channel of the inadvertently placed catheter.
The technical success rate for stent grafts was high, although the technique calls for caution when used close to major arterial side branches.

Little is known about the long-term durability in terms of stenosis, kinking and fracture, although recent findings suggest that their use can be comparable to that of open surgery for carotid or subclavian injuries.34,35 None of our patients had clinical signs of local complications to the intervention. Hence, although stent grafts might not be the first choice in younger patients, their use can be advantageous when the puncture site is not compressible and difficult to access with open surgery.

Conclusions

Inadvertent arterial positioning of central venous catheters might be associated with obesity, emergency puncture, severe hypotension or low haemoglobin saturation, and the risk has been reported to be lower under ultrasound guidance. Useful clinical warning signs of arterial catheterisation are excessive or pulsatile backflow, local haematoma or sudden neurological deficit. Any suspected intra-arterial catheter position should be verified radiographically and the catheter be left in place on referral for repair. Percutaneous/endovascular management of inadvertent arterial catheterisation appears to be safe and feasible and seems to offer advantages over open surgical repair in selected patients.

Conflict of Interest/Funding

None.

Acknowledgements

None.

References

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