A Survey Of Venous And Arterial Cannulation Techniques Used For Routine Adult Coronary Artery Bypass Grafting

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Abstract

A postal questionnaire was used to survey current techniques for arterial and central venous access for routine adult coronary artery bypass grafting. The study population was the 303 members of the Association of Cardiac and Thoracic Anaesthetists (ACTA); of whom 64% returned completed responses. The findings are discussed with reference to current literature.

INTRODUCTION

A questionnaire study was designed to survey the techniques of venous and arterial cannulation currently used for routine adult coronary artery bypass grafting by cardiac anaesthetists throughout the UK, and provide a snapshot of current clinical practice.

METHODS

In October 2000, postal questionnaires were sent to all 303 members on the Association of Cardiac and Thoracic Anaesthetists' (ACTA) mailing list. The total number of completed questionnaires returned from the 260 members actively engaged in adult cardiac anaesthesia was 166(64%). The shortfall was due to non-reply and change of address. Data were entered onto an IBM-compatible PC using Access (Microsoft Corporation), and analysed using Statview 5.0 (SAS Institute Inc., Cary, NC).

RESULTS

PERIPHERAL VENOUS CANNULATION

139(83.7%) of the respondents routinely established peripheral intravenous access for induction with a single cannula although 25(15.1%) used two cannulae, and 2(1.2%) used three cannulae. 152(92.8%) anaesthetists preferred to use a 14 gauge cannula, 12(7.2%) favoured a 16g, and 6(3.6%) favoured an 18g cannula. However 7(4.2%) anaesthetists used a smaller cannula (20-23g) for induction, to minimise patient discomfort; relying on subsequent central venous cannulation for fluid administration. The forearm was the preferred site of peripheral cannulation by 113(68.1%) anaesthetists; the dorsum of the hand by 46(27.7%); the antecubital fossa by 12(7.2%) and the external jugular vein by 1(0.6%).

There was considerable variation in the brand of peripheral cannulae used, but the majority of anaesthetists 83(51.9%) used Venflons.

ARTERIAL CANNULATION

All anaesthetists used a single arterial cannula, with the exception of one who routinely cannulated both the radial and the femoral arteries. The radial artery was the vessel of choice for 163(98.2%) anaesthetists. 2(1.2%) anaesthetists routinely used the brachial and 1(0.6%) used both the radial and the femoral arteries.

The majority of anaesthetists 155(93.4%) used a 20g cannula to cannulate the radial artery. However 8(4.8%) used a 22g cannula. Some stated that they used a smaller cannula because it facilitated radial artery cannulation. 3(1.8%) did not specify the preferred size of cannula. Allen's test was routinely used by only 24(14.5%) of respondents.

If the first choice of arterial access was unsuccessful, 95(69.9%) of anaesthetists who expressed a preference for second choice used the brachial artery, 37(27.2%) used the femoral, 3(2.2%) used the ulnar and 1(0.7%) used the dorsalis pedis arteries.

Techniques for arterial cannulation varied. 113(68.1%) anaesthetists preferred to use direct cannulation, 41(24.7%) used transfixion and 12(7.2%) used the Seldinger technique.

CENTRAL VENOUS CANNULATION

The majority of anaesthetists 146(88.5%) routinely secured

central venous access after induction of anaesthesia; however cannulation prior to induction in an awake or sedated patient was used by 19(11.5%).

The preferred vessel for central venous access by 156(94.6%) anaesthetists was the right internal jugular vein (IJV). 7(4.2%) anaesthetists preferred the right subclavian vein (SCV) and 2(1.2%) preferred the left SCV. If the preferred vessel could not be cannulated, 126(76.4%) anaesthetists used the left IJV as the second site of choice. 21(12.7%) used the right SCV, 8(4.9%) used the left SCV, 6(3.6%) used the right IJV (if not used as first choice), and 4(2.4%) used right external jugular vein (EJV).

INTERNAL JUGULAR VEIN CANNULATION

The table was routinely tilted head-down by 141(84.9%) anaesthetists, and kept flat by 16(9.6%); the remainder expressed no preference. The neck-piece of the table was routinely extended by 13(7.8%) anaesthetists.

140(84.3%) anaesthetists turned the patient's head away from the site of insertion, 19(11.5%) kept the head in the neutral position (one respondent commented that this was "the key to success"), and the remainder expressed no preference. The pillow was routinely removed from behind the head by 35(21.1%) anaesthetists, and 50(30.1%) routinely extended the patient's neck prior to cannulation. A sandbag or pillow was placed between the shoulder blades by 39(23.5%) anaesthetists.

The landmarks used to locate the IJV varied widely, and were utilised in a variety of combinations. Ballotment or palpation of the vein was used by 83(50.0%) respondents, 76(45.8%) used palpation of carotid artery pulsation, 58(34.9%) used the angle between the sternal and clavicular heads of sternocleidomastoid, 50(30.1%), used the mastoid process and sternal notch, and 24(14.8%) respondents used the cricoid cartilage. Other landmarks used included: the trachea, thyroid cartilage, thyroid notch, and a point 3 fingers breadth above the sternal notch.

After choosing the insertion point using the landmarks described above, 118(78.7%) anaesthetists routinely directed the seeker or main needle laterally (ie. towards the ipsilateral nipple, to avoid hitting the carotid artery); 24(16%) directed the needle along the saggital plane, and 8(5.3%) medial to the saggital plane.

The number of central venous cannulae inserted ranged from 1-5 (Mean 1.42, SD 0.66). When more than one cannula was used, the most common combination was that of a quadruple lumen cannula with a Pulmonary Artery Flotation Catheter (PAFC) sheath. A variety of central venous cannulae were used. 89(53.6%) anaesthetists routinely used a triple lumen cannula, 59(35.5%) used a quadruple lumen cannula, 6(3.6%) used a double lumen cannula, and 1(0.6%) used a single lumen cannula. PAFC sheaths were routinely inserted by 48(28.9%) of anaesthetists, with a PAFC being used by 18(37.5%). All the above were inserted using the Seldinger technique. In addition, 19(11.5%) anaesthetists used single lumen rigid cannulae without guidewires (eg. Wallace Flexihub, Angiocath, Baxter MCA); often in combination in preference to a multilumen cannula; and one anaesthetist claimed to routinely use no less than four 14g plus one 16g Angiocaths for this purpose!

A Doppler ultrasound probe ("SiteRite") was used by only 30(18.1%) anaesthetists as an aid to IJV cannulation. These anaesthetists used it in a mean of 24.8% cases (SD 40.4). The Doppler ultrasound was used by 21 anaesthetists to demonstrate the vein prior to cannulation, whereas only 9 used it to cannulate the vessel under direct vision.

79(47.6%) anaesthetists reported no complications of IJV cannulation within the last year. Reported complications included: carotid artery puncture or cannulation by 76(45.8%); pneumothorax by 7(4.2%); and subclavian vascular damage due to the guidewire by 6(3.6%) respondents. Other complications reported included: a haemothorax of 400 ml requiring surgical drainage, iatrogenic ventricular tachycardia due to stimulation of the myocardium by the guidewire, and three cases of significant haematoma; one of which was in a patient with pre-existing coagulopathy. One respondent stressed the importance of adequately securing IJV cannulae with sutures to prevent accidental dislodgement peri- and post-operatively; especially in the case of "fast track" patients, who tend to be more agitated following extubation. 3.2% anaesthetists who used the right IJV as their first choice route for central venous cannulation reported the complication of iatrogenic pneumothorax within the last year; compared to 14.3% and 50.0% of those who favoured the right and left SCV approaches respectively.

A seeker needle was routinely used to aid IJV cannulation by only 41(24.7%) of anaesthetists; 51(30.7%) used a seeker needle infrequently, often adding "only if the approach is difficult"; and the majority did not use a seeker needle 74(44.6%). The percentage of anaesthetists who reported the

complications of pneumothorax, arterial puncture or inadvertent cannulation, and subclavian vascular damage occuring within the last year in each of these groups was 41.5%; 66.7%; and 48.6% respectively. The percentage of anaesthetists reporting inadvertent carotid artery cannulation was 19.5%; 49.0% and 31.1% respectively. The percentage of anaesthetists reporting carotid artery puncture was 12.2%; 13.7% and 10.8% respectively.

OTHER MONITORING PROCEDURES

146(88.0%) anaesthetists used PAFCs to measure cardiac output intraoperatively. Those who did so used it in a mean of 18.1% cases (SD 24.75). 108(65.1%) anaesthetists used Transoesophageal Echocardiography (TOE) to measure cardiac output intraoperatively. Those who did so used it in a mean of 19.2% cases (SD 19.4). Other techniques for cardiac output monitoring included PiCCO 4(2.4%) and Lithium dilution with pulse contour analysis 2(1.2%).

DISCUSSION

This study is limited by a relatively small sample size, and by the fact that results are derived from retrospective self-reporting of usual practice and complications, rather than a detailed prospective audit of individual cases. However the following trends are apparent:

The most commonly used technique overall is:

Peripheral iv access with one 14g Venflon in the forearm. Direct cannulation of the radial artery with a 20g cannula (Allen's test not performed). Central venous access performed with the patient anaesthetised in the head down position (without pillow removal and without a sandbag behind the shoulders). One triple lumen cannula; or a combination of a PAFC sheath with catheter for cardiac monitoring, and a quadruple lumen cannula; inserted in the right IJV using the Seldinger technique (insertion point determined by ballotment or palpation of the IJV; or by palpation of the carotid artery).

ARTERIAL CANNULATION

Although the majority of anaesthetists routinely used only one arterial cannula sited in the radial artery, there are advantages in having a second cannula sited in the femoral artery. If only one arterial cannula is used for both monitoring invasive blood pressure and for blood sampling perioperatively, blood pressure monitoring is not available during acquisition of blood samples. During this time hypo or hypertension may go undetected with potentially adverse consequences. If the single cannula or sampling line becomes kinked or occluded, the facility for both monitoring and sampling is lost, leaving the anaesthetist in a difficult predicament. In this situation, it is useful to have a second line to use as a back-up. Insertion of a second arterial line into the femoral artery after induction is a quick and simple procedure which should prevent such problems. Systolic blood pressure measured via the peripheral (radial) arteries may result in an overestimate compared with central (femoral or direct aortic) measurement ([1]). Immediately following cardiopulmonary bypass, the reverse situation occurs, with radial arterial measurement underestimating "true" aortic pressure by 1-5% ([2]). If only one arterial cannula is used perhaps the femoral rather than the radial route should be considered.

The routine use of Allen's test to check for adequate collateral flow via the ulnar artery prior to radial artery cannulation is no longer recommended as it has poor sensitivity and specificity ([3,4,5,6]) and this appears to be reflected in the practice of the majority of anaesthetists surveyed.

CENTRAL VENOUS CANNULATION

94.6% of respondents used the right IJV as the route of choice for central venous cannulation. The right IJV is preferred, as it offers a more direct route into the superior vena cava, avoids injury to the thoracic duct, and is easier for the right handed operator ([7]). The left IJV is less direct and therefore has more potential for malposition of the cannula than the right IJV approach; but is a suitable route of second choice if the right IJV cannot be cannulated; and this was the second choice of 126(76.4%) respondents in our study.

The majority of respondents performed central venous cannulation in anaesthetised rather than awake patients. As well as being more comfortable for the patient, the failure rate of central venous cannulation by inexperienced physicians has been shown to be significantly less when performed in anaesthetised rather than conscious patients ([8]). The failure and complication rate increases as the number of percutaneous punctures increases (8, [9]), probably because of distortion of anatomical landmarks by small haematomas. It has been suggested that after three attempts, an alternative route be used ([10]).

In this survey, fewer anaesthetists reported the complication of an iatrogenic pneumothorax within the last year for the

right IJV approach than for either the left or right SCV approaches. More anaesthetists reported pneumothoraces associated with the left compared to the right SCV approach, which may represent the fact that the former may be more difficult for a right handed anaesthetist to perform; however these associations should be interpreted with caution in view of the design of the survey.

Inability to cannulate the IJV using a blind percutaneous technique may occur in over 19% cases, depending on the level of experience of the operator (8). The most frequent complication associated with this technique is arterial puncture ([11], [12]) and has resulted in expensive civil actions for damages ([13]). In a prospective study of 1284 patients, the incidence of carotid artery puncture was found to be 3.9% (11).

There are many techniques for blind percutaneous cannulation of the IJV ([14]). Ultrasound studies have shown that in 8.5% of patients the anatomy of the IJV is sufficiently abberant to complicate access by a blinded method ([15]). Common causes of abnormal IJV anatomy are thrombosis and scar tissue resulting from previous multiple or long-term cannulation (15).

Previous studies have shown that the use of Doppler ultrasound significantly reduces the number of attempts, the incidence of failed cannulation, and the time taken for central venous cannulation; and is also useful as a teaching aid (15,16,17,[18],[19],[20]). Using the ultrasound probe for real time localisation and catheter placement, rather than solely for vessel localisation, has been shown to decrease the complication rate and improve success rate for IJV and SCV cannulation ([16]). It may be preferable to use the probe to guide cannulation under direct vision, as distortion of anatomy may occur during needle insertion, and with some techniques a second operator is required to manipulate the probe ([17]). However, a minority claim that the use of ultrasound may not be helpful, as it is operator dependant and associated with a significant learning curve (9, [21]). It has been recommended that Doppler ultrasound should be used routinely to aid cannulation of all central veins under direct vision, and should not be used purely as a back-up technique for cases which are anticipated to be difficult, or in which previous blind cannulation has been unsuccessful (13, 15, [22]). In this study, many anaesthetists did not have routine access to this apparatus, however this trend may change in the near future, as the use of a Doppler assisted technique during central venous cannulation may become a medio-legal requirement (13).

The use of a seeker needle as an aid to blind IJV cannulation has been a controversial issue. Opponents point out that the use of a seeker needle and the main needle will cause two holes in the vessel instead of one. The time and expense of the procedure will be increased, and the seeker needle may cause venous spasm making insertion of the main needle more difficult ([23]). The seeker needle may reduce the incidence of venous transfixion ([24]). A large trial would be required to determine if the use of a seeker needle decreased the incidence of arterial puncture with the main needle ([25]). This information is not currently available. If a 20g seeker needle accidentally punctures the carotid artery, a small haematoma may result with no significant clinical effects. However in a heparinized patient undergoing cardiopulmonary bypass, carotid artery puncture or cannulation by a 16g cannula may result in a large haematoma which may distort the anatomy, preventing further attempts at cannulation; postponement of surgery, haemorrhage requiring surgical intervention, or even death (11, [26]). In the absence of Doppler ultrasound, it has been recommended that a seeker needle technique should be used and taught to anaesthetists in training (11, 25, [27]). Anaesthetists who use seeker needles infrequently tend to reserve this technique for high-risk cases in whom difficulties in cannulation are anticipated.

A wide variety of maneuvers were used to maximize the diameter of the IJV, and thereby increase cannulation success and decrease complications. Realtime ultrasound studies (15, [28], [29]) have demonstrated that the most effective method of increasing IJV diameter is to use a Valsalva manouevre (or positive end expiratory pressure in an anaesthetised patient), which may increase the IJV diameter by 50%. Steep (>20 degree) Trendelenberg tilt and the use of abdominal binders also significantly increase IJV diameter (28-[30]).

The majority of anaesthetists in this survey routinely turned the patient's head to the contralateral side, and this may aid access to the neck. Turning the head does not affect the size of the IJV if the patient is in the horizontal (28) or head down (30) position. However, turning the head may change the anatomic relation between the IJV and the carotid artery, causing the IJV to lie anteriorally rather than laterally to the carotid artery, predisposing to carotid artery puncture if the cannulating needle traverses the IJV (22). A minority routinely extended the neck, removed a pillow, or extended

the head-piece of the table. Full neck extension may decrease the size of the IJV (28), making successful cannulation more difficult. 45.8% of anaesthetists used palpation of the carotid artery as a landmark to locate the IJV. However, gentle pressure on the neck during palpation of the carotid artery may reduce the diameter of the IJV (28, 29). It is therefore recommended that after the position of the artery is found and marked, it should not be palpated during needle insertion (28).

This study represents a "snapshot" in time of current clinical practice. A recent study has examined preferred techniques for central venous cannulation in neurosurgery (10), however little data exists of preferences in cannulation techniques for coronary artery bypass grafting. Triple lumen cannulae were introduced 15 years ago (Vygon, personal communication). Prior to this, central venous access in adult patients undergoing cardiac surgery in the UK was commonly achieved using bilateral drum catheters inserted in the antecubital veins. It is hoped that repeating this study in future will enable us to follow other changing trends in clinical practice.

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SURVEY OF INTRAVENOUS AND ARTERIAL LINES FOR ROUTINE CARDIAC SURGERY

(I) PERIPHERAL INTRAVENOUS ACCESS

(a) How many peripheral IV lines do you routinely insert ?

- one
- two
- three

(b) What sizes of cannulae do you use for peripheral IV access ?

- 14G
- 16G
- 18G

(c) hat is your preferred site of cannulation ?

- Dorsum of hand
- Wrist
- Antecubital Fossa

(d) What type / make of cannulae do you use ?

- Venflon
- Abbocath
- Wallace
- Other

(II) ARTERIAL CANNULATION

(a) How many arterial cannulae do you insert ?

- One
- Two

(b) What size cannula do you use ?

- 22G (blue)
- 20G (pink)
- 18G (green)

(c) What is your preferred site of arterial cannulation ?

- Radial Artery
- Brachial Artery.
- Femoral Artery.

(d) What is your second preference for site of arterial canulation ?

- Radial Artery
- Brachial Artery
- Femoral Artery

(e) What technique do you use for radial artery canulation ?

- Direct Cannulation
- Transfixation
- Use of Seldinger technique.

(f) Do you perform Allen's test before radial artery canulation ?

- Yes
- No

(III) CENTRAL VENOUS ACCESS

(a) Do you routinely establish central venous access with the patient

- Awake ?
- Anaesthetised ?

(b) How many central venous catheters do you insert ?

- One
- Two

(c) What type of central line do you use ?

- Single lumen rigid catheter (e.g. Wallace with flexi hub)
- Single lumen with Seldinger wire technique
- Double lumen
- Triple lumen
- Swan Ganz sheath with PA catheter
- Swan Ganz sheath without PA catheter.
- Other

(d) What is your preferred site for central venous cannulation ?

(e) What is your second preference for site of central venous cannulation ?

INTERNAL JUGULAR VEIN CANNULATION.

(a) How do you position the patient for internal jugular vein cannulation ?

1. Position of the table:
3. Flat
4. Head down tilt
5. Flat with neck extended.

1. Position of head:
3. Head neutral position with pillow.
4. Head turned away from site of insertion
5. Neck extension

1. Do you use sandbag or pillow between the shoulders ?
3. Yes
4. No

(b) What anatomical landmarks do you use for location of internal jugular vein ?

- Carotid artery pulsation
- Cricoid cartilage
- Mastoid process and sternal notch
- Sternocleidomastoid muscle (angle between the sternal and claricular heads)
- Internal jugular vein palpation
- Other

(c) Which direction do you insert the needle ?

- Saggital plane
- Lateral to the saggital plane e.g. pointing towards the ipsilateral nipple
- Medial to the saggital plane

(d) What technique do you use to identify the internal jugular vein ?

- Use of seeker needle
- Use of Doppler ultrasound to demonstrate the vein prior to cannulation
- Cannulation under direct vision using Doppler ultrasound.

(e) At what level is your skin puncture point ?

- Above the cricoid cartilage.
- Levelled with the cricoid process.
- Below the cricoid cartilage.

COMPLICATIONS

What complications have you had from central venous cannulation in your clinical practice ?

- None
- Hematoma
- Carotid artery cannulation
- Pneumothorax
- Subclavian vascular damage
- Other

(IV) OTHER MONITORING PROCEDURES

On what percentage of patients in your routine practice do you perform transeophageal echocardiography?

On what percentage of patients do you use pulmonary artery catheterisation?

How do you measure Cardiac output?

- Continuous
- Intermittent Thermodilation
- Other

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