Case Report

ECG recording of central venous catheter misplaced in inferior thyroid artery

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A 71-year-old male patient with liver metastases secondary to rectal carcinoma was scheduled for hemi-hepatectomy. Two months earlier he had undergone subtotal resection of the thyroid gland. Prior to surgery, a triple-lumen catheter and an introducer sheath were introduced into the right internal jugular vein using a landmark technique. No problems occurred during insertion of the triple-lumen catheter, but resistance was noticed during insertion of the 8.5 FG introducer sheath. After placement of the introducer sheath, intra-arterial misplacement was confirmed using a pressure transducer. The opportunity was taken to record and compare intravascular ECG by the arterial and venous catheters before removal. No difference was noticed in the P-wave patterns; both showed a marked increase. Surgical exploration of the neck, recommended by the vascular surgeon consulted, showed that the carotid artery was not injured. The introducer sheath had completely punctured the right internal jugular vein and entered the inferior thyroid artery. A thrill was felt. The management of this case is discussed, with suggestions for best practice. Intravascular ECG was unhelpful in differentiating between venous and arterial placement of the catheter.

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Central venous catheterization is associated with various complications including inadvertent arterial injuries, pneumothorax, haemothorax, injury to the thoracic duct and pericardial tamponade.1 This unusual case of inferior thyroid artery cannulation illustrates one potential danger of internal jugular vein catheterization and its complications. We describe a transvenous arterial misplacement of a large-bore catheter and discuss the management of these complications. Finally, we question the validity of ECG guidance for correct central venous catheter positioning and explain how the expected rise in P-wave amplitude may be misleading.

Case report

A 71-year-old male patient was scheduled for left-sided hemi-hepatectomy because of central metastases of a rectal carcinoma. Two months earlier he had undergone bilateral subtotal resection of a multinodular thyroid gland. After induction of anaesthesia, a standard landmark technique was used for central venous cannulation. The right internal jugular vein was cannulated 2 cm lateral to the carotid artery pulsation approximately 4 cm above the clavicle and dark blood slowly dripped from the 18 gauge steel needle. A guidewire was inserted into the vessel without any resistance. The same vein was punctured using the same technique approximately 2 cm above the first cannulation site. At that time, the oxygen saturation measured by pulse oximetry was 100%. Once more dark blood appeared and a second guidewire was inserted, meeting no resistance. Following skin incision and dilation of the tissue, a triple-lumen catheter (Certofix™ Trio SB 730, 7 French, B. Braun Melsungen AG, Melsungen, Germany) was inserted into the vein using the upper guidewire. The triple-lumen catheter was placed under ECG guidance and sutured in place.

Resistance was noticed during insertion of an 8.5 FG introducer sheath (SI-09875-E, Arrow Deutschland, Erding,
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Germany) using the lower guidewire, despite a wide skin incision. The guidewire was bent but not kinked when it was removed. After placement of the introducer sheath, there was difficulty injecting saline solution. We also noticed that the aspirated blood was brighter than that obtained from the triple-lumen catheter. Connection of the introducer sheath to a pressure transducer showed blood pressure values typical of an artery, and the shape of the pressure wave indicated a position within a central artery.

Since we have performed several previous studies of the validity of intravascular ECG guidance, we took the opportunity to record an intra-arterial ECG via the guidewire that did not protrude beyond the tip of the catheter (Fig. 1).

Because of the high risk for complications after removal of an introducer sheath, we consulted a vascular surgeon. Surgical exploration of the neck showed that the carotid artery was not injured. The introducer sheath had completely punctured (transfixed) the right internal jugular vein and entered the inferior thyroid artery, which was apparently enlarged. A thrill due to the passage of blood between the wall of the artery and the obstructing large-bore catheter was felt. The inferior thyroid artery was ligated, the sheath removed, and the anterior and posterior walls of the internal jugular vein were sutured. Following successful hepatectomy, no further complications were observed.

Discussion

The insertion site for central venous cannulation preferred by most anaesthesiologists is the right internal jugular vein, with success rates using this approach reported to be ~88–95%.23 It is recognized that there is wide variation in vessel anatomy, which can result in unsuccessful attempts even in experienced hands. The complication most cited, inadvertent carotid artery puncture, occurs approximately 5% of the time.4 Cannulation of other arteries in close proximity to the cannulated artery to the internal jugular vein would have been noticed. Forward needle movement decreases the intraluminal distending pressure, causing compression or obliteration.

Ultrasound-guided cannulation of the internal jugular vein significantly improves success rate, decreases average access time and reduces complication rate. This technique should be preferred in complicated cases or when access problems are anticipated, as in our case. The proximity of the cannulated artery to the internal jugular vein would have been noticed. Forward needle movement decreases the intraluminal distending pressure, causing compression or obliteration.

suprascapular, the transverse cervical and the inferior thyroid arteries.

The inferior thyroid artery normally runs upwards behind the internal jugular vein, continuing in the same direction as the thyrocervical trunk. This was where our introducer sheath had entered the inferior thyroid artery. Usually this artery is of small calibre but it may increase in size with enlargement of the thyroid gland, as in this case. Accidental cannulation of this artery is rare. Just below the level of the lower margin of the cricoid cartilage the inferior thyroid artery gives off its ascending cervical branch and then passes medially and usually somewhat downwards, making an arch behind the carotid sheath, and reaches the posterior aspect of the thyroid gland. As the right vagus nerve passes across the subclavian artery it gives off the right recurrent nerve, which turns below and then behind the artery to ascend in the neck. The lack of hoarseness in our patient suggests that there was no nerve damage in this case.78 Any of these adjacent structures can easily be punctured while attempting internal jugular vein cannulation, especially when the vessels do not lie in the ‘typical’ orientation, which is the case in up to 5–8% of the population.38

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Fig 1 Intravascular ECG traces recorded through malpositioned introducer sheath (aorta) and central venous catheter placed correctly in the superior vena cava (SVC).

Fig 2 Anatomy of the neck: some relations and branches of the subclavian arteries. The right internal jugular vein (IJV) has been partially ‘removed’ to visualize the inferior thyroid artery.
This needle-induced compression can probably not be avoided but argues for maximizing internal jugular vein lumen size and minimizing needle resistance by selecting a needle with the smallest possible diameter. Therefore, we prefer cannulation with an 18 gauge thin-walled needle to the cannula-over-needle technique.

Initially, arterial puncture may escape detection because blood flow and colour may not be reliable indicators. Resultant neck haematoma is usually minor. However, subsequent large-bore catheter insertion into an artery may lead to a more serious complication. The rate of actual insertion of large-bore catheters in the carotid artery is 0.1–0.5%. In our case the most likely mechanism for the inadvertent arterial placement of the introducer sheath is an initial correct cannulation of the internal jugular vein followed by dislodgement of the needle during insertion of the guidewire. This resulted in transfixion of the internal jugular vein and cannulation of the adjacent internal thyroid artery. An initial inadvertent arterial puncture is also conceivable. No resistance was felt on insertion of the guidewire. Therefore the technique of inserting a plastic cannula and reinserting the guidewire was not considered. However, for safer practice before inserting a large-bore catheter the following technique is advisable: (1) replacement of the steel needle by a plastic cannula gently advanced over the guidewire, which is then removed; (2) confirmation of the intravenous position of the cannula by observing a central venous pressure waveform.

Kinking of the plastic cannula, resulting in false low-pressure readings or pressure waveforms, is unlikely if there is no resistance to the removal and reinsertion of the guidewire. In the case described, primary inadvertent arterial cannulation would have been revealed by this technique. Also, the operator must immediately be suspicious that the dilator is not following the intended path if the guidewire cannot be gently slid back and forth or even resists manipulation during dilator insertion.

While prevention of arterial cannulation is certainly the best option, once this complication has occurred adequate management is essential, especially with large-bore catheters. Severe morbidity and even mortality may occur, particularly in conjunction with systemic heparinization for cardiopulmonary bypass.

Once the catheter is removed, direct pressure may be difficult to place on the artery because it is usually distal to the puncture site in the skin. The airway may then become obstructed by an enlarging haematoma causing deviation of the trachea. Inadvertent arterial cannulation with a large bore catheter may result in serious vascular injury, excessive blood loss and neurological complications. Therefore, if possible, a vascular surgeon should be consulted prior to removal of the catheter. The surgeon must decide whether to explore the vessel and what type of repair may be required, and the decision to delay the scheduled procedure will depend on its urgency. Any unstable patient should have a surgical exploration performed. Pre-existing carotid artery disease or neurological complications may also be an indication for immediate exploration.

Although surgical exploration of the neck of our patient was performed 30 min after the incident, a palpable thrill was felt due to the passage of blood between the wall of the artery and the obstructing large-bore catheter. The incidence of arteriovenous fistula formation after large-bore catheter insertion into an artery is low, ranging from 0.01% to 0.6%. Arteriovenous fistulae may not involve immediate high risks but may lead to oedema or arterial insufficiency downstream of the involved region. It is even possible that congestive heart failure may occur. Clinical suspicion, based on the presence of a continuous murmur and/or a thrill in the involved area, may be confirmed by colour Doppler ultrasound. Angiography allows a more complete definition of the fistula site and size. Large-bore catheters such as introducer sheaths and haemodialysis catheters are most frequently involved in fistula formation.

In our opinion, early surgery is definitely the best therapeutic option. The odds for spontaneous closure are low, and the results of non-surgical interventions (percutaneous stenting, percutaneous embolization, ultrasound-guided compression) are not always satisfactory.

Intravascular ECG is an established method of determining the position of the catheter tip. A guidewire serves as the exploring ECG electrode and usually Einthoven lead II is monitored. It is generally accepted that the P-wave amplitude increases as the catheter enters the right atrium. However, there is a false assumption that an increase in P-wave amplitude is only associated with intravenous/right atrial positioning. Another case report on an inadvertent carotid artery cannulation also showed an expected P-wave increase via ECG guidance. This ECG phenomenon was later interpreted in a review article as evidence of a left intra-atrial catheter malposition. From our observations, however, it is implausible that the catheter had passed the aortic and mitral valves. Rather, it must have been situated in the ascending aorta beyond the pericardial reflection. In pigs, an increase in P-wave amplitude indicates that the exploring electrode is within the pericardium, irrespective of whether the electrode is in an artery or vein. This case confirms this in humans, and we conclude that intravascular ECG monitoring is not useful for differentiating between venous and arterial placement of a central venous catheter (Fig. 1).

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