

## Deceptive jugular manometry, blood colour and $P_{O_2}$ in the presence of an ipsilateral upper extremity arteriovenous fistula: a report of two cases

David M Corda\*\*  and Stephen Aniskevich III<sup>b</sup>

<sup>a</sup>Department of Anesthesiology, University of Florida College of Medicine, Gainesville, USA

<sup>b</sup>Department of Anesthesiology and Perioperative Medicine, Mayo Clinic College of Medicine, Jacksonville, USA

\*Corresponding author, email: [dcorda@anest.ufl.edu](mailto:dcorda@anest.ufl.edu)



Manometry, blood gas analysis and colour of blood are often used as adjuncts to verify central venous access and rule out inadvertent arterial puncture. Several clinical scenarios may make these techniques unreliable. Two cases are presented involving patients with mature upper arm arteriovenous fistulas in which techniques to confirm correct central venous access contradicted ultrasound imaging findings.

**Keywords:** arteriovenous fistula, central venous catheter, manometry, ultrasound

**Case reports:** A 24-year-old woman with a history of severe lupus-related autoimmune hepatitis and end-stage renal disease presented for orthotopic liver transplant. She had been on intermittent haemodialysis via a mature right upper arm arteriovenous fistula (AVF). Placement of a 9-French introducer via the right internal jugular (RIJ) vein guided by live ultrasound (US) was planned for haemodynamic monitoring and access for large-volume fluid resuscitation. After ultrasound-guided 18-ga intravenous catheter (IV) access of the presumed RIJ vein, bright-red non-pulsatile blood at high pressure was encountered. To exclude the possibility of arterial puncture, the catheter was connected to a transducer that displayed a weakly pulsatile pressure of approximately 44 mmHg. A sample of blood drawn from that catheter appeared arterial by gross colour inspection and was submitted for blood gas analysis (Table 1) along with a paired radial arterial sample for comparison. The  $P_{O_2}$  measured 324 mmHg compared with the blood sample obtained from the radial artery with a  $P_{aO_2}$  of 367 mmHg. The possibility of inadvertent carotid artery cannulation could not be excluded. Another possible source of well-oxygenated blood and modestly high pressures was the high-output AV fistula on the ipsilateral side of the line placement, which may have resulted in significant admixture near the line entry site. To verify venous cannulation and reject possibility of inadvertent arterial puncture, colour flow Doppler US was used and showed a characteristic compressible non-pulsatile flow in the vessel with the IV catheter tip visible in the compressible vessel and distinct from the visible ipsilateral carotid artery. The site was then dilated and the introducer placed without issue.

In a second case, a 59-year-old dialysis-dependent male with a history of suspected bowel ischaemia presented for exploratory laparotomy. Similar to the first patient, this gentleman had been receiving dialysis through a mature proximal right upper extremity AVF. Due to poor peripheral venous access, an attempt was made to place an RIJ triple lumen central venous catheter under ultrasound guidance. As before, despite ultrasound confirmation of the needle placed into the RIJ, hollow tubing attached to the needle displayed uncharacteristic venous properties.

Blood in the tubing transduced as a vertical column held in the air was bright red and steadily rose to approximately 40 cm above the patient's chest. In order to better assess needle placement given these findings, a tourniquet was briefly applied to the patient's right upper extremity proximal to the fistula. Upon placement of the tourniquet, the transduced column of blood quickly dropped to approximately one-quarter of its previous height. This manoeuvre confirmed that the AVF admixture had significantly contributed to venous return and caused a discrepancy when confirming needle placement. The jugular vein was then dilated with successful RIJ venous cannulation.

### Discussion

Central venous catheters are essential for the clinical management of many patients. The internal jugular vein is a target of choice amongst many anaesthesiologists because of its calibre and accessibility from the head of the operating room table. It is also readily visible by ultrasound and thus lends itself to ultrasound-guided access while carrying a very low risk of pneumothorax compared with subclavian catheter placement. Even though risks are low, cannulation of the internal jugular vein has been associated with many acute and long-term complications, the most frequent being inadvertent puncture of the carotid artery.<sup>1,2</sup> An arterial puncture rate as high as 4.2% has been reported.<sup>3</sup>

Despite the advent and more widespread availability of modern ultrasound to help confirmation of proper jugular vein access, other techniques such as transducing a column of blood by allowing it to fill a connected length of IV tubing remain a common routine for some practitioners.<sup>4</sup> With these techniques, many anaesthesiologists are aware of haemodynamic circumstances (e.g. severe tricuspid regurgitation, superior vena cava syndrome, steep head down position and congestive heart failure) that may alter manometry findings and cause electronically transduced venous blood to appear extremely high in pressure or even somewhat pulsatile. This may be misleading and misinterpreted as an inadvertent arterial puncture.

Table 1: Blood gas comparison

	Central venous catheter	Radial artery	Units
pH	7.386	7.407	
Pco <sub>2</sub>	49.2	47.8	mmHg
Po <sub>2</sub>	324	367	mmHg
So <sub>2</sub>	99.9	99.9	%
HCO <sub>3</sub>	30.0	30.7	mmol/L
Hgb	12.3	12.2	g/dl

In the cases presented, neither patient had preoperative indications of valvular pathology, cardiac defects or elevated right ventricular end diastolic pressures to cause confounding results after RIJ puncture. It is clear that the existence of an ipsilateral high-output AV fistula was the confounding factor creating a markedly elevated RIJ venous pressure and waveform. The occurrence of a high-output AVF causing increased cardiac output and elevated right-sided pressures has been reported.<sup>5</sup> In fact, a mature AVF may contribute up to 28% of resting cardiac output.<sup>6</sup> In both of the cases presented, a large volume of blood from the fistula with higher oxygenation returned to the RIJ vein via the right brachiocephalic vein. This phenomenon was noted in the distant past by Yee *et al.* who placed two cannulas in an internal jugular vein and found discrepancies in oxygenation and colour of blood when sampling at different sites in the same vein.<sup>7</sup> In 2004, Angaramo *et al.* applied digital pressure on the venous limb of an AVF to prevent inaccurate interpretation in a patient similar to ours.<sup>8</sup> In the second case presented, prior knowledge of this phenomenon allowed us to recognise the situation and placement of a temporary tourniquet eliminated the discrepancies.

A growing number of patients are being maintained on dialysis via upper extremity arteriovenous fistulas. We share these cases as a reminder to anaesthesiologists placing internal jugular vein catheters in a patient with an ipsilateral upper extremity arteriovenous fistula so that they might either consider accessing the side contralateral to the AVF to prevent confounding information from confirmatory line placement tests or, as an alternative, consider imposing a temporary obstruction of the AVF while verifying that the intended IJ vein was in fact accessed to alleviate any uncertainties.

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#### ORCID

David M. Corda  <http://orcid.org/0000-0001-9821-0652>

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