conventional ventilation before starting oscillation, but also because of the fact that she had multiple bilateral air leaks and had five chest drains in situ at the time of starting oscillation. Her oxygenation improved, she did not develop any further air leaks, and the existing pneumothoraces resolved while she was on the oscillator.

It may well be that this unconventional form of ventilation not only has a role in the management of ARDS but that its success in the treatment of air leaks in children,\(^{11-13}\) and in animal studies,\(^{14,15}\) may also be applicable to adults.

References


Apparent hyperkalaemia from blood sampled from an arterial cannula

V. Mehta* and Z. Ahmed

Boyle Department of Anaesthesia, St Bartholomew Hospital, West Smithfield, London EC1A 7BE, UK

*Corresponding author. E-mail: vmehta1971@hotmail.com

Blood samples were obtained from a radial artery cannula in a 60-yr-old man during coronary artery surgery. Serum potassium concentrations of 9.3, 8.4, and 7.4 mmol litre\(^{-1}\) were obtained. A simultaneous venous blood sample gave a serum potassium concentration of 4.4 mmol litre\(^{-1}\). The ECG was unchanged. After the arterial cannula was repositioned, subsequent blood samples gave expected ranges of serum potassium concentration. We suggest that the initial arterial cannula position caused a high shear rate in the blood when samples were withdrawn, causing haemolysis and hyperkalaemia.

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Keywords: arteries, cannulation; complications, catheter misplacement; complications, hyperkalaemia; ions, potassium

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Arterial cannulation can cause many complications such as haemorrhage, infection, peripheral ischaemia, air and clot embolism, vascular damage with aneurysm, pseudo aneurysm, or arterio-venous fistula. We report a patient in whom a radial arterial cannula caused haemolysis in blood samples withdrawn from it.

### Case report

A 60-yr-old man was about to have an elective coronary artery surgery procedure. He gave a history of angina at rest and shortness of breath on moderate exertion. A venous blood sample analysis gave sodium 139 mmol litre\(^{-1}\), potassium 4.6 mmol litre\(^{-1}\), urea 7.6 mmol litre\(^{-1}\), and creatinine 117 mmol litre\(^{-1}\). The left radial artery was cannulated with a 20 gauge arterial cannula (Abbocath) with some difficulty, and connected to an arterial pressure monitoring system with a pressure transducer (Medex) filled with a saline and connected to an arterial pressure monitoring with a 20 gauge arterial cannula (Abbocath) with some difficulty. The left radial artery was cannulated with a 20 gauge arterial cannula (Abbocath) with some difficulty. A right radial arterial cannula was inserted into the radial artery posterior to the brachioradialis muscle and the cannula was slightly withdrawn. A further sample was obtained (sample 5), which gave a potassium concentration of 9.3 mmol litre\(^{-1}\). The ECG did not show signs of hyperkalaemia, and other observations were normal (Table 1). The blood potassium value was suspected to result from a fault in analysis. Another sample (sample 2) was obtained from the right radial arterial cannula and analysed with a different apparatus, which gave a potassium value of 8.4 mmol litre\(^{-1}\). The patient’s vital signs and ECG remained unchanged. Two further samples were obtained simultaneously from arterial and venous cannulae and analysed on the first analyser. The arterial sample value remained unchanged. Two further samples were obtained (sample 4), which gave a potassium concentration of 4.1 mmol litre\(^{-1}\), and further blood samples obtained from the cannula had expected potassium values.

### Discussion

Arterial cannulation is a common procedure in surgery and intensive care, to allow arterial pressure monitoring and repeated blood gas sampling. One estimate suggests that approximately 8 and 2.5 million arterial cannulae are placed each year in the USA and Europe, respectively. Hyperkalaemia caused by cannula malposition has not been reported. In an Australian Incident Monitoring Study (AIMS-ICU) with a total of 7525 reports, 251 reports were related to arterial cannulae alone, totalling 376 incidents. Out of these 376 incidents, 69 (19%) were related to patient injury but none were associated with hyperkalaemia. A review of approximately 20 000 radial artery cannulations did not report local haemolysis.

We suggest that in this patient the tip of the cannula could have impinged against the vessel wall so that red blood cells were damaged when a blood sample was obtained. During withdrawal of the sample, a high shear rate caused by narrowing of the cannula orifice or lumen could have caused haemolysis leading to an increased potassium concentration in the blood samples.

A high shear rate and static pressure can damage erythrocytes. A positive static pressure of 600 mm Hg alone did not cause haemolysis, but shear rates of 500 s\(^{-1}\) and greater caused haemolysis with a static pressure of 0 mm Hg. We found hyperkalaemia with two different analysers. Arterial and venous samples obtained simultaneously and analysed on the same analyser showed that the samples had different values and that equipment failure was not possible.

Systemic hyperkalaemia caused by heparin is a rare but recognized complication and has been described during cardiopulmonary bypass. However, this was not the cause in our patient who was subsequently fully anticoagulated with heparin without hyperkalaemia.

A badly positioned aortic cannula during cardiopulmonary bypass has been described in a child, resulting in hyperkalaemia and renal failure.

After we suspected the possible cause of hyperkalaemia, we repositioned and adjusted the arterial cannula and repeatedly flushed it with heparinized saline. Subsequent sampling gave satisfactory results. No harm came to the patient. Red cell haemolysis can be measured using a haemorheologic assay that includes estimates of erythrocyte mechanical fragility, plasma total protein and fibrinogen concentrations, blood viscosity, and free haemoglobin. We could not use these measures to confirm our suspicions of the cause of hyperkalaemia in this case, but they should be considered if haemolysis is suspected to be caused by hyperkalaemia. Awareness of this complication of arterial cannulation should prevent inappropriate therapy to adjust potassium concentration. Abnormal values in a sample from a cannula after difficult cannula insertion should be held in suspicion, and a venous sample should be withdrawn to check the analysis.

### Table 1 Blood gas and electrolyte values

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>08:38</th>
<th>08:39</th>
<th>08:50</th>
<th>08:50</th>
<th>08:53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Arterial</td>
<td>Arterial</td>
<td>Arterial</td>
<td>Venous</td>
<td>Arterial</td>
</tr>
<tr>
<td>pH</td>
<td>7.39</td>
<td>7.39</td>
<td>7.47</td>
<td>7.42</td>
<td>7.46</td>
</tr>
<tr>
<td>Pco(_2) (kPa)</td>
<td>5.64</td>
<td>5.37</td>
<td>4.47</td>
<td>5.21</td>
<td>4.28</td>
</tr>
<tr>
<td>Po(_2) (kPa)</td>
<td>57.0</td>
<td>49.5</td>
<td>58.2</td>
<td>7.0</td>
<td>58.8</td>
</tr>
<tr>
<td>K(^{+}) (mmol litre(^{-1}))</td>
<td>9.3</td>
<td>8.4</td>
<td>7.4</td>
<td>4.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Na(^{+}) (mmol litre(^{-1}))</td>
<td>134</td>
<td>137</td>
<td>137</td>
<td>134</td>
<td>1</td>
</tr>
</tbody>
</table>

\(\text{O}_2\) (kPa) 57.0 49.5 58.2 7.0 58.8
\(\text{CO}_2\) (kPa) 5.64 5.37 4.47 5.21 4.28
Right thoracic paravertebral analgesia for hepatectomy


Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, NT, Hong Kong SAR, People’s Republic of China

*Corresponding author. E-mail: hoamh@cuhk.edu.hk

Haemostatic deficiencies, common among cirrhotic patients, may deteriorate further after hepatectomy, increasing the bleeding risk associated with the use of thoracic epidural analgesia. We describe two patients who enjoyed immediate post-operative tracheal extubation and satisfactory analgesia using mainly right thoracic paravertebral analgesia after right lobe hepatectomy.

Keywords: analgesia; anaesthesia, regional; anaesthetics, local; complications, coagulopathy; complications, thrombocytopenia

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Hepatocellular carcinoma affects more than 500 000 people globally each year.1 Over 75% of hepatocellular carcinomas are caused by persistent hepatitis B or C.1 Some patients undergoing hepatectomy also suffer from hepatitis-induced cirrhosis, decreased hepatocyte mass and coagulopathy. During and after surgery, further loss of liver mass and possibly intra-operative liver ischaemia, often lead to an initial decline in coagulation function, typically at its worst level on the first-to-second post-operative day.2–4 In addition, thrombocytopenia may be present as a result of portal hypertension, reduced plasma thrombopoietin, or both.5 6 Coagulopathy and thrombocytopenia may be contraindications to central neuraxial blockade. Although many hepatectomy patients could be managed after surgery in a high dependency unit with parental analgesics such as patient-controlled morphine,7 some would benefit from more intense forms of analgesia with minimal central nervous system depression. Recently, in an effort to reduce post-hepatectomy intensive care needs and to improve patient comfort, we began exploring the use in hepatectomy patients of thoracic paravertebral analgesia, a technique already used extensively in our centre for surgery involving the chest and upper abdomen. Compared with epidural analgesia, this technique probably carries a much lower risk of spinal haematoma in the presence of moderate haemostatic deficiencies.8 9

Case reports

Case 1
A 49-yr-old Chinese woman (height 151 cm, weight 72 kg) with chronic hepatitis B and radiological evidence of cirrhosis was scheduled to undergo right lobectomy for hepatocellular carcinoma. She was otherwise in good health,