Intra-atrial ECG guidance for positioning central vein catheters

Editor—We read with interest the article by Schummer and colleagues1 on the use of intra-atrial ECG guidance for positioning central venous catheters in the superior vena cava. They arrived at the same conclusion as we did in 1993 in our study.2 We found this method reliable and cost-effective for checking the correct position of a central venous catheter. We studied 350 patients and the puncture was left-sided in 45 patients. After seeing an augmented peaked P-wave, indicating that the tip of the catheter lies in the right atrium, the catheter was slowly withdrawn until the P-wave started to diminish. After the catheter had been withdrawn a further 1–2 cm, its tip was thought to lie as required in the superior vena cava. In our study, we used 20 cm long polyurethane central venous catheters. After insertion, the mean depth of the catheter, measured from the lower edge of the clavicle to the tip of the catheter was 5.7 cm (SD 2.4) in all patients and 5.1 cm (SD 2.8) in those whom the method failed; this difference was statistically insignificant.

This method, however, may fail in patients when catheterization is done high in the neck veins and/or from the left side of the body, as well as in patients with myocardial pathology and in elderly males who have pulmonary emphysema. In these cases, we recommended the use of catheters longer than 20 cm to achieve a typical intra-atrial ECG.

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Editor—I read with interest the article by Schummer and colleagues1 on the unreliability of placing internal jugular vein catheters via ECG. Based on 20 yr experience in neuroanaesthesia at the Mayo Clinic in Rochester, Minnesota, USA, where we placed 200–250 of these annually, I suggest an amendment to their technique. Our insertion site was an antecubital vein, but that is immaterial.

The authors’ technique of catheter placement (page 482, right hand column, lower third): ‘The catheter was then advanced, together with the guide wire, until an increase in P-wave size was detected. Both catheter and guide wire were then withdrawn until the P-wave returned to normal size’. Contrary to their title, this is not an intra-atrial ECG technique, but a supra-atrial technique.

A unipolar intravascular ECG (four standard limb leads, with the V lead attached to the external end of the guide wire or a saline-filled catheter), functions as a probing intra-vascular electrode via its tip. There is a positive deflection when current flows toward this electrode, and a negative deflection when it flows away. The P-wave depolarizes down the right atrium from the SA node, away from an electrode in the superior vena cava (SVC), and is therefore negative. The amplitude of the P-wave is governed by the inverse square rule, that is amplitude is inversely proportional to the square of the distance from the current source. Thus the P-wave increases greatly in negative amplitude as the catheter approaches the atrium. When the tip enters the atrium, it is just beyond the SA node, and the first portion of the P-wave depolarizes towards it. This results in a brief small positive deflection followed instantly by a deep negative deflection. Figure 1 displays an acute ECG.3 Figure 2 shows the corresponding anatomical position of the catheter when the ECG is recorded.4

Schummer and colleagues did not enter the atrium, but withdrew the catheter when it was close to it, still in the lower SVC. Had they entered the upper atrium and then withdrawn, perhaps there would have been fewer unwanted angles greater than 40°.

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Fig 1 Patient ECG,3 (A) Catheter tip in lower SVC. (B) Catheter tip in lower SVC, now very close to atrium. (C) Catheter tip in upper atrium. Published with permission of the Editor of the American Journal of Anesthesiology and the author of the article in which the figure appeared.
Editor—Thank you for giving us the opportunity to reply to the interesting letters from Salmela and Aromaa, and from Gronert.

In their investigation, Salmela and Aromaa studied mainly subclavian vein cannulations (n=233) with a ratio of left to right=1:7.2 We had a well-balanced ratio of left- (n=57) to right-sided (n=53) internal jugular vein (IJV) catheterizations (Salmela and Aromaa: nine left IJV and 54 right IJV catheters). In addition, we did address the issue of catheter impingement.3 Salmela and Aromaa identified loop formation, pace-maker-ECG, cardiomyopathy, atrial fibrillation, and too short a catheter as the reasons for failure of ECG-guided central venous catheter (CVC) placement.

Especially in left-sided CVCs, we agree that, if the catheter tip is located in the SVC parallel to the lateral vessel wall, 20-cm catheters are often too short. Thirty-eight of our 57 left-sided catheters had been inserted for more than 20 cm. Five of these catheters had been positioned 1 cm distal to the crista terminalis. None of our right-sided catheters had been inserted by more than 20 cm.

However, we strongly disagree that measuring the distance between the lower edge of the clavicle and the catheter tip on a chest radiograph is a reliable method to assess correct position. The vast majority of bedside radiographs are taken in the anterior-posterior (AP) position. Accurate estimation of the degree of cardiac magnification on a given AP radiograph has several major limitations:5 6 one would have to know the target–film distance and the patient’s AP diameter to determine magnification; magnification also varies with the diameter of the patient’s heart; patient’s position causes important variations with small changes in the radiation resulting in large distortions on the chest X-ray (radiation–wave angle) (Fig. 3).

In our publication we do not mention that Einthoven lead II was used as the ‘intra-atrial’ lead. In contrast to the V-lead illustrated by Gronert (Fig. 2), the P-wave deflection in these circumstances is positive.

Gronert might be right in his assumption that we finally obtained a supra-atrial ECG when positioning the catheter. This is actually the point we wanted to make with our publication. It is claimed that the P-wave increases in positive amplitude as the intra-atrial lead approaches the SA node. The manufacturer of the Certodyn adapter, B. Braun (Melsungen, Germany), describes the so-called ‘intra-atrial’ ECG lead method for placement of CVCs as follows: ‘The catheter is initially advanced to the point where an elevated P-wave is visible on the electrocardiogram; then it is retracted by 2 cm. The ECG returns to normal. The loss of an elevated P-wave is a clear signal of the catheter’s position above the right atrium’.7 The Food and Drug Administration published a precautionary statement regarding positioning of CVCs stating that ‘the catheter tip should not be placed in or allowed to migrate into the heart’.8 As we were dealing with cardiovascular patients suffering from for example ischaemic heart disease or aortic stenosis, we abstained from advancing the CVC deep inside the heart for safety reasons. Nevertheless, we used the technique described by the manufacturer.

Initially, we did advance the catheter until the P-wave increased markedly in size and thus we believe that we did enter the right atrium. However, we did not check this by transoesophageal echocardiography. Then we did retract the catheter back into the SVC as described by the manufacturer. Catheters with hampered blood flow through any of the lumina were re-advanced until proper function was achieved. Four of the nine impinging catheters had already been re-advanced. Therefore we conclude that normalization of P-wave amplitude does not occur in the lower SVC close to the SA node. In another study, accepted for publication, we could show that LIJV-catheters readvanced by 1–3 cm beyond the site of P-wave normalization resulted in extra-atrial positions, without catheter impingment.9 Being clinicians and not specialists in electro-physiology, we observed that there must be additional factors influencing the P-wave amplitude than...
just the distance to the SA-node. We presumed that the pericardial reflection is the site of first P-wave increase as a result of alteration in the volume conductor resistivity of the connective tissue. This is 3-fold as high as that of blood.

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8 Administration FaD. Precautions necessary with central venous catheters. FDA Task Force. FDA Drug Bull 1989; 15–16

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