Arterial Line Placement

Safety First

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ARTERIAL lines are regularly inserted in patients in the perioperative and critical care setting to measure hemodynamic variables, such as beat-to-beat blood pressure and cardiac output, and to regularly obtain blood gas values and other measurements from plasma. In the research setting, arterial lines are occasionally inserted for measurements that cannot be obtained from other sources. For example, arterial samples are often more valuable than venous samples in the pharmacokinetic–pharmacodynamic modeling studies.[1] In this issue of Anesthesiology, Nuttall *et al.*[2] describe the possible risk factors related to severe arterial line complications in adult patients undergoing a large variety of surgical procedures. They report on more than 62,000 arterial lines placed in more than 57,000 patients in a 7-yr period (2006 to 2012) at Mayo Clinic in Rochester, Minnesota. For almost 56,000 times, the catheter was placed in the radial artery. The authors detected a severe complication rate in a small minority of patients ranging from 2.7 to 12.3 per 10,000 patients depending on the location of the arterial line. On average 8 per 10,000 patients developed a serious complication. The data indicate that arterial line placement has a low complication rate, and consequently we feel confident to state that arterial line placement, when performed by qualified personnel, is a safe medical procedure.

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Focusing on the radial artery, which in clinical and research settings is the most common site of arterial line placement, Nuttall *et al.* reported on just 15 cases with a severe complication. Most frequent complications were related to thrombotic occlusion of the radial, ulnar, and/or brachial arteries or vasospasm, leading to symptoms in the affected hand that included lost radial pulse, pain, numbness, paresthesia, cool mottled skin, and local cyanosis. Additional complications included neuropathy due to nerve damage, bleeding, and pseudoaneurysm formation. It is important to realize that in eight cases, no intervention was required as symptoms resolved spontaneously.

It seems surprising that cannulation of the radial artery, a vessel just 2.5 to 5 mm in diameter,[3] does not lead more frequently to serious complications. This is especially true when realizing that asymptomatic temporary occlusion of the radial artery on cannulation is quite common and occurs in up to 35% of patients.[4] This is partly related to the collateral circulation in the hand. The radial ulnar arteries are connected through deep and superficial palmar arches from which digital arterial branches perfuse the digits.[3] Consequently, adequate reserve in perfusion is available when one of the arteries becomes occluded. Some variation in the anatomy of the palmar arches is evidently present with an incomplete superficial arch in 16% of patients; the anatomy of the deep arch is much less variable, and an intact arch may be assumed in most patients.[3] In addition, recruitment of nonfunctional capillaries and new capillary formation in response to tissue hypoxia from prolonged and possibly even acute vessel occlusion may occur.[5] The safety of radial artery cannulation is further confirmed by data from children and the large body of evidence from the cardiology literature.[5,6] Already in 1987, Selldén *et al.*[5] showed safety of long-term placement of a 22-gauge (0.8 mm) radial arterial catheter in children and neonates admitted to the intensive care unit

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or operating room. The cardiology data show that coronary angiography and coronary intervention (such a coronary stent placement) using the transradial access is considered safe with ischemic complications rarely reported.[6] The occurrence of severe complications, as described by Nuttall *et al.*[1] and others,[6] may be explained by embolization from the primary thrombus causing occlusion of end arteries.

Most anesthesiologists and cardiologists apply the Allen test to assess the vascular patency of the hand before cannulation of the radial artery.[7] The Allen test is simple: The patients make a fist, after which both ulnar and radial arteries are occluded. The hand is then reopened and appears white (pallor). The release of pressure on the ulnar artery should lead within 15 to 20 s to hyperemia of the skin. A positive result of the test is that pallor persists, suggestive of the absence of collaterals between the radial and the ulnar arteries. Given the above, it seems reasonable to question whether the Allen test is sufficiently sensitive in predicting vascular patency and complications after radial artery placement. McGregor[8] showed in 1987 that in six patients with a positive Allen test, dye injected *via* the radial artery spread through the entire hand on ulnar artery occlusion, whereas initially it was retained to the thumb and thenar eminence. The author concluded that the Allen test is "of no clinical value." In a recent discussion article, Shah *et al.*[6] make a convincing case for the limited value of the Allen test or the adaptation of the test in which digital plethysmography is used as a monitor of vascular patency. One of the studies they discuss is from Valgimigli *et al.*[9] who showed that patients with a positive Allen test display signs of enhanced collateral perfusion originating from the ulnar artery after radial artery cannulation.

So far we discussed radial artery placement in patients undergoing surgical or cardiological procedures. The first studies that report on arterial catheter insertions in healthy volunteers date from the late 1970s and early 1980s. Also in our clinical research unit, we regularly insert 22-gauge arterial lines in the radial artery of healthy volunteers involved in hemodynamic or pharmacological studies. Since the year 2000, we placed 980 arterial lines in 895 volunteers. Before starting, the procedure was comprehensively discussed with the institutional review board (IRB). The IRB granted permission and stipulated scrupulous monitoring, including questionnaires to be filled in by the research subjects and periodical reporting to the IRB. Evidently, the risk–benefit consideration of an arterial line in healthy subjects is not comparable with the considerations made in relatively sick patients undergoing often complex surgeries with possibly hemodynamic instability. In healthy volunteers, the placement of an arterial line should be carefully weighed between the scientific benefit (*e.g.*, the harvesting of rich data collected from beat-to-beat hemodynamic measurements or frequent drug samples from plasma) and the possible complications. The data from Nuttall *et al.* certainly help in this respect. Their observation of a low complication rate is mirrored by our own observations. In the 15 yr that we insert arterial lines in volunteers, we observed one complication: the formation of a painful pseudoaneurysm in a 22-yr-old female subject, which resolved spontaneously within weeks without residual complaints. If the research benefits of arterial catheterization in healthy volunteers are considerable, it would appear that they are well worth the very small risks of this medical procedure.

Competing Interests

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