Editorial

Invasive monitoring of blood pressure: a radiant future for brachial artery as an alternative to radial artery catheterisation?

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The arterial catheter provides reliable measurements of arterial blood pressure (BP), even in the event of minimal or absent pulsatility as observed during low flow states, cardiopulmonary bypass or extracorporeal membrane oxygenation treatment. Abrupt changes in BP are instantly and accurately detected with beat-to-beat invasive BP monitoring. Repeated sampling of arterial blood is made easy by the arterial catheter. BP waveform analysis (respiratory variation of the pulse pressure, for instance) may guide fluid management (1). Cardiac output can be determined from the BP signal, via user-friendly devices (2). For all these reasons, invasive monitoring of BP with an arterial catheter is standard practice during major surgery and severe critical illness (3).

The radial artery is the most common catheterised site for BP monitoring (4,5). Femoral artery catheterisation is the widely used alternative, especially when transpulmonary thermodilution measurements are required. Of note, in some institutions, the brachial artery is the first choice (6). Other proposed sites of cannulation for BP monitoring are the axillary, dorsalis pedis, ulnar or tibial posterior arteries (5).

Cannulation of the radial artery: advantages and disadvantages

Owing to its low rate of complications, the radial artery is the preferred site for invasive BP monitoring (3,4). The radial artery is often easily accessible in the operating room, is not adjacent to important nerves and has a collateral supply network. Indeed, below the antecubital fossa, i.e., below the bend of the elbow, the brachial artery divides into the radial and ulnar arteries and both form the arterial blood supply to the forearm and the hand, the palmar arches being fed by these two arteries (7). This collateral flow reduces the risk of hand ischemia in the event of catheter-induced arterial thrombosis (3).

The risk of large haematoma is lower with the radial compared to the femoral artery puncture, for instance (8). In addition, the radial approach is associated with fewer catheter-related bloodstream infections than the femoral site (9).

However, some of the disadvantages of the radial artery approach may make physicians opt for other sites. Thus, the radial artery could be hardly palpated in hypotensive patients contrary to larger, more proximal arteries (5). In addition, radial artery BP may not reflect central aortic BP, i.e., may differ from the BP at the organ-level. Indeed, the systolic BP is amplified from the aorta towards peripheral arteries, whereas mean and diastolic BP only slightly changes (10). It is the so-called pulse pressure amplification phenomenon. Briefly, the change in impedance from the aorta to the capillary produces reflected pulse waveforms. The addition of forward (incident) and backward (reflected) pulse waves increases the systolic BP at the radial level as compared with aortic BP. Again, in most patients, the measurements of mean and diastolic BP are not—or only slightly—impacted by the site of measurement (10,11). Since mean and diastolic components of BP are the primary determinants of the perfusion pressure of most organs, the clinical superiority of proximal over radial artery BP monitoring is unclear (11,12). However, in certain circumstances, a significant central-to-radial arterial pressure gradient may involve mean and diastolic BP measurements as well. It often occurs in cardiac surgery after cardiopulmonary bypass (13-15). The aetiology of this gradient is multifactorial and may include, along with predisposal factors, cardiopulmonary bypass-induced haemodilution and decrease in viscosity yielding changes in peripheral resistance, or, for some authors, a radial artery vasoconstriction (15).

These pathophysiological considerations make some physicians prefer a more central BP monitoring via femoral or brachial artery catheterisation (6).

Catheterisation of the brachial artery: theoretical advantages and risks as compared with the femoral approach

The lack of studies rigorously comparing the brachial and the femoral approaches for BP monitoring is noteworthy. However, some specific risks could be mentioned.

With the femoral technique, the close proximity to the perineum is often seen as a risk factor for catheter-related infection. As compared with the femoral approach, the brachial artery catheterisation may be associated with a lower risk of catheter-related infection. Indeed, 2011 guidelines from The United States Centers for Disease Control and Prevention stated that "*In adults, use of the radial, brachial or dorsalis pedis sites is preferred over the femoral or axillary sites of insertion to reduce the risk of infection*" (9). Of note, the rate of brachial artery catheter-related infections was understudied at the time of these guidelines.

Haematoma and pseudoaneurysm formation can occur with both techniques (for the femoral approach, respective incidences of 6% and 0.3%) (5). However, with the femoral technique, the diagnosis of abundant haemorrhage in the groin or the retroperitoneal space is often delayed.

In the antecubital fossa, the brachial artery is adjacent to the median nerve which could be damaged during the arterial puncture attempts (16). After femoral artery puncture, neuropathy can also occur either through direct damage of the femoral nerve by the needle or through nerve compression by groin or retroperitoneal haematoma even causing lumbar plexopathy involving the femoral, obturator, or lateral femoral cutaneous nerves (17).

Besides thrombotic or air distal embolism, which are nonspecific to the chosen site of cannulation, the most dreaded complication of the brachial approach is the occlusion of the brachial artery, yielding ischemia of the forehand and the hand, since collateral arteries are lacking (7). Hence, years earlier, guidelines recommended against the brachial artery approach for BP monitoring in children (9) or even in all patients (3). Beyond obvious anatomical considerations, the lack of strong clinical evidence supporting this recommendation is noteworthy. Owing to the lack of collateral circulation, the femoral approach also carries a risk of limb ischaemia (temporary occlusion in 1.5%, permanent damage in 0.2%) (5).

What is the actual incidence of complications during brachial artery BP monitoring?

Several recent studies in the perioperative setting may shed light on this issue. Handlogten *et al.* retrospectively reported that, in various surgical procedures in a single centre, 3 adult patients out of 858 (0.35%) receiving brachial artery catheterisation experienced vascular complications but no infectious or neurologic complications. Two out of these 3 patients required surgical thrombectomy (18). In the same study, a group of 3,432 patients with radial catheterisation did not experience any vascular complication (18). In another recent retrospective study, among 1,617 brachial artery cannulations, mostly for cardiac surgery, only 2 vascular complications occurred (one requiring surgical thrombectomy) (4). In a single-centre retrospective study among neonates and small children undergoing cardiac surgery, 3 (0.8%) temporary occlusions of the brachial artery occurred but no permanent ischaemic damage or pseudoaneurysm formation among 386 brachial cannulations, a complication rate similar to that of a cohort of patients with radial artery catheterisation (19).

Singh *et al.* recently evaluated the incidence of brachial artery catheter complications in a single-centre retrospective cohort of adults undergoing brachial artery cannulation for BP monitoring during cardiac surgery (6). Among 21,597 patients, i.e., the largest cohort reported to date, 41 had complications definitely or possibly related to the brachial artery catheter, yielding an incidence of 0.19% (95% CI, 0.14–0.26). Vascular complications occurred in 33 patients [0.15% (95%CI, 0.10–0.23)]: 21 experienced upper extremity ischemia and 1 had compartment syndrome of the forearm. Thrombectomy was required in 18 patients, fasciotomy of the forearm in one, amputation in none, and surgical repair of the brachial artery in 8 patients. Brachial artery catheter possibly related infection occurred in 8 patients. No median nerve injury has been identified.

In summary, the authors of those recent studies advocated the relative safety of the brachial artery catheterisation (4,6,18,19).

Could brachial artery cannulation be a safe option whatever the setting?

Whether the low incidence of brachial artery catheter complications reported in those studies in the perioperative setting could be extrapolated to other settings is uncertain, as acknowledged by Singh *et al.* (6). Several arguments can be advanced in favour of a cautious use of the brachial approach.

First, the low incidence of complications of brachial artery BP monitoring reported in the above-cited single-centre studies is actually the incidence observed in institutions where physicians are well-trained in brachial artery cannulation (6,18). The incidence of complications could be higher in less experienced settings, since there is an association between the number of puncture attempts and infectious and vascular complications (3).

Second, the reported incidence of complications only corresponds to that of intra-arterial catheters inserted in the operating room, in optimal safety conditions (4,6,18,19).

Third, in those studies reporting low incidences of complications in adults, 20-gauge catheters were mostly used (6,19). The use of larger catheters could be associated with more complications (4).

Fourth, the incidence of complications of brachial BP monitoring is unknown for a longer duration of catheterisation, in intensive care unit patients for instance. The duration of catheterisation was not provided in the two largest studies in the perioperative setting (4,6) but one could assume that, in most patients, the brachial artery catheter was removed within the 24–48 hours after its insertion, as it was reported in another perioperative population (18). Since there is an association between infectious and thrombotic complications, on the one hand, and the duration of catheterisation on the other hand (20), one may dread a significantly higher incidence of complications if the intra-arterial brachial catheter is maintained several days.

Fifth, peripheral arterial disease is associated with increased risk of complications of brachial BP monitoring [odds ratio of 2.78 (1.11–7.01)] (6). Of note, in studies reporting a low incidence of complications, only 2–11% of the adult patients had peripheral arterial disease (4,6,18). Therefore, brachial artery cannulation should probably be discouraged in patients with peripheral arterial disease. Indeed, even if, in such patients, the thrombotic risk of other cannulation sites is also increased (7), a thrombosis of the radial artery rarely causes ischemia of the hand (4,5), especially if the collateral blood flow via the ulnar artery is adequate. This is illustrated by the fact that the radial artery can be harvested for coronary artery bypass graft surgery (7). In addition, contrary to most other sites of cannulation, there are means proposed to safely select patients to radial artery cannulation or harvest, such as the Modified Allen's Test for instance (7).

Last, most studied patients have undergone cardiac surgery. In this specific setting, the use of anticoagulants and platelet inhibitors is frequent (6) and could have prevented the occurrence of catheter-related thrombosis.

Clinical implications and perspectives

In summary, in specific circumstances, recent data are reassuring about the risks associated with brachial artery monitoring of BP (4,6,18). This is important when the radial pulse is not palpable, when the radial artery is thin, when there is contra-indication to intra-arterial catheter placement at the wrist or when very accurate monitoring of systolic and diastolic BP is required, in the cardiac surgery setting for instance. In these patients, the femoral artery site is commonly seen as the first alternative choice to radial artery BP monitoring. Recent studies reporting a low incidence of complications with brachial artery catheterisation could make more physicians opt for the brachial artery rather than the femoral artery. This would be especially true if the possible lower risk of catheter-related infectious complications with brachial rather than with femoral catheterisation is definitely proven in the future.

However, to our opinion, as for the femoral site approach, caution should still be exercised when invasive brachial BP monitoring lasts several days, in patients with peripheral arterial disease, not receiving anticoagulants/platelet inhibitors and/or when the operator is unexperienced in brachial catheter insertion. Hence, as for the femoral artery site, a careful regular assessment should aim at an early detection and treatment of the most dreaded complication: a critically compromised perfusion of the hand and forehand. Of note, the widespread use of ultrasonography to guide vascular-catheters insertion could further decrease the rate of complications of brachial BP invasive monitoring, as for other cannulated vessels. Indeed, the use of ultrasonography was relatively infrequent (18) or not mentioned (4,6) in the above-cited studies. Ultrasonography allows the visualization of the needle, the artery and the surrounding structures increasing the first attempt success rate and shortening the procedure duration (21). Ultrasonography may also allow assessing the artery diameter to guide the choice of the catheter size. In addition, and even if this issue has been poorly studied, ultrasound-guidance could be a means to insert a radial catheter in a more proximal position than the wrist, overcoming the frequent anatomic variations of limb arteries (7,22). Last, whatever the site of cannulation, ultrasonography is a suitable means to confirm a clinically suspected reduced flow in the hand.

In conclusion, provided that care givers regularly and rigorously assess the adequacy of hand perfusion, avoid protracted durations of catheterisation especially among patients with peripheral arterial disease, brachial artery cannulation could be a safe alternative to radial artery for short-term BP monitoring.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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