

The present and future of indwelling arterial catheter: An anesthesiologist's perspective

Onur Koyuncu^{1,2*}, Steve Leung², Asha Singh³ and Alparslan Turan²

¹Department of Anesthesiology and Reanimation, Tayfur Ata Sökmen Medical Faculty, Mustafa Kemal University, Hatay, Turkey

²Department of Outcomes Research, Anesthesiology Institute, Cleveland Clinic, Cleveland, Ohio, USA

³Cardiothoracic Anesthesiology, Anesthesiology Institute, Cleveland Clinic, USA

Introduction

Continuous blood pressure measurement with plastic catheters was first described by Peterson in 1949. Indwelling arterial catheters (AC) are commonly placed in the operative period and critical care setting to provide continuous hemodynamic monitoring and blood sampling. Approximately 8 million ACs are placed in the United States annually [1] and about one-third of all critically ill patients in this nation receive an AC [2]. The view that beat-to-beat knowledge of hemodynamics would translate to improved patient care and clinical outcomes was widely held among anesthesiologists, and so ACs become the standard of care for complex surgeries or high-acuity patients.

ACs are routinely used for cardiac surgery, neurosurgery (such as cerebral aneurysm) and certain types of patients (such as uncontrolled hypertension, hemodynamic instability or shock, liver transplants). Similarly, ACs are clearly unnecessary in healthy patients having minor or moderate-risk procedures, such as most ophthalmic surgeries. However, there are a broad range of patients in whom ACs might reasonably be used or avoided.

Potential benefits of arterial catheters

The number one indication of AC placement in the intraoperative period is tight management of hemodynamics, especially in settings where hypotension and large fluid shifts are anticipated. Observational evidence shows an association between hypotension and morbidity/mortality among patients undergoing non-cardiac surgery [3-7]. For example, even brief periods of hypotension, defined as mean arterial pressure less than 55 mmHg, is associated with substantial increased risk of postoperative acute kidney injury [3]. Similarly, in a large case-control study by Bijker et al., showed that intraoperative blood pressure less than 30% from baseline is associated with increased risk of postoperative ischemic stroke [5]. Furthermore, the multicentered PeriOperative ISchemic Evaluation (POISE-1) trial suggested an association between intraoperative hypotension and adverse outcomes after non-cardiac surgery, including all-cause mortality and stroke at 30 days after surgery. The authors have suggested hypotension to be a major contributor to these adverse events [6].

Besides the available data for continuous hemodynamic monitoring, ACs also allows repeated arterial blood gas samplings, laboratory, and coagulation testing. An AC is thus used for patients with significant ventilator, metabolic, electrolyte and fluid/blood requirements. Measurement of the partial pressures of arterial oxygen and arterial carbon dioxide provides more valuable information about the status of gas exchange than *arterial oxygen saturation, especially in*

patient with severe pulmonary disease. Moreover, the arterial waveform-pulse pressure variation, systolic pressure variation and pulse contour analysis-stroke volume variation predicts fluid responsiveness during fluid resuscitation.

Potential complications with arterial catheters

Radial artery is the most common site for cannulation because of easy access and collateral circulation of the hand. The less preferred sites for arterial cannulation are femoral, axillary, brachial, dorsal pedis, tibialis posterior, ulnar arteries. Femoral artery is the second most common cannulation site because of the larger lumen and closer representation of aortic pressure. The cannulation of temporal artery causes serious complications like cerebral embolization because of the association with external carotid artery. Severe complications associated with AC are estimated to occur in less than 1% of cases [8]; although rare, it is important to realize that such complications, if arises, can be severe and lead to significant patient harm.

Vascular complications especially temporary thrombotic occlusion of the artery is the most common complication, with incidence of 1.5% to 35% [8], and is secondary to catheter induced vessel wall integrity changes [9]. Distal ischemia can also occur as a consequence of thrombosis, embolization, or local spasm after arterial catheterization interventions. Serious ischemic damage requiring treatment appears to be exceedingly rare with incidence of 0.09%-0.2%, but nonetheless there are multiple reports of hand ischemia as a result of radial AC, some leading to tissue necrosis and amputation of digits [10-12]. Other common complications are hematoma formation at the site (14%), bleeding (0.53%) infection at the cannulation site (0.72%) and sepsis (0.13%) [8]. Another serious complication is pseudoaneurysm formation, with increased risk of rupture and thromboembolism, and usually requiring either ultrasound guided medical intervention or surgical management [13,14].

A rare but serious complication linked to AC placement is nerve injury with incidence of approximately 1% [15] although risk of permanent damage is exceedingly rare. Nerve injury is likely caused by either direct trauma from needle during placement or compression injury as a result of expanding hematoma at cannulation site. Other

Correspondence to: Onur Koyuncu, Department of Anesthesiology, Mustafa Kemal University, Tayfur Ata, Sokmen Medicine Faculty, Serinyol, Hatay, Turkey, Tel: 90-326-2291000, **E-mail:** onurko@yahoo.com

Received: March 30, 2016; **Accepted:** April 27, 2016; **Published:** April 29, 2016

complications such as air embolism, compartment syndrome [15], unintentional intra-arterial injection [16], abscesses [17] have been reported but are rare.

ACs are also associated with increased healthcare resource utilization. The direct cost of AC includes the cost of the AC kit, transducers and the time it takes for AC placements. Besides the cost of the supplies (A-line kits and transducers) there often is significant insertion time in case of hypotension, may delay surgery. Arterial lines have also been dubbed “faucets from which blood flows” and contribute significantly to unnecessary laboratory tests (such as blood gas and coagulation testing) and iatrogenic anemia. It has been shown previously that even after adjustment for disease severity; patients with ACs have a 44% increased blood volume drawn compared to those without ACs [18] and exposes patients to increased need for transfusions [19].

Whether the routine use of ACs confers quantifiable meaningful benefits to the care of the patients is unknown; thus the optimal rate of use of the catheters is unclear. So there is no clear standard in AC usage between physicians; some clinicians prefer more than the others. In a recently published study by Gershengorn et al. who performed a propensity-matched cohort on more than 139 intensive care units nationwide, reported that ACs were not associated with improvements in mortality in patients requiring mechanical ventilation [20].

Conclusion

Most of the time the widely use of ACs without evidence for benefit is likely due to belief that invasive monitoring is superior and blind acceptance. But it should not be forgotten that the most important thing is do no harm to patients in medicine “Primum non nocere: first do not give harm”. Given the lack of empirical evidence of benefits of ACs and wide acceptance of its use, randomized trials are needed to better clarify whether the use of ACs improves outcomes in the operative setting. On the basis of our findings, AC placement is a relatively safe procedure with rare serious complications. AC, if used in the right patient population, can yield information about a patient's physiological status, but should be tailored to the patients' individual physiological status and clinical settings.

Acknowledgements

Dr. Onur Koyuncu was supported by a grant for life expenses from TUBITAK: Technology and Innovation Support Programs, Directorate of the Scientific and Research Council of Turkey.

References

- Gardner RM (1990) Direct arterial pressure monitoring. *Current Anaesthesia & Critical Care* 1: 239-246.
- Gershengorn HB, Garland A, Kramer A, Scales DC, Rubenfeld G, et al. (2014) Variation of arterial and central venous catheter use in United States intensive care units. *Anesthesiology* 120: 650-664. [[Crossref](#)]
- Sun LY, Wijesundera DN, Tait GA, Beattie WS (2015) Association of intraoperative hypotension with acute kidney injury after elective noncardiac surgery. *Anesthesiology* 123: 515-23. [[Crossref](#)]
- Hallqvist L, Mårtensson J, Granath F, Sahlén A, Bell M (2016) Intraoperative hypotension is associated with myocardial damage in noncardiac surgery: An observational study. *Eur J Anaesthesiol* 33: 450-456. [[Crossref](#)]
- Bijker JB, Persoon S, Peelen LM, Moons KG, Kalkman CJ, et al. (2012) Intraoperative Hypotension and Perioperative Ischemic Stroke after General Surgery A Nested Case-control Study. *Anesthesiology* 116: 658-664. [[Crossref](#)]
- Devereaux PJ (2008) Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial. *Lancet* 371: 839-1847.
- Sessler DI (2012) Hospital stay and mortality are increased in patients having a “triple low” of low blood pressure, low bispectral index, and low minimum alveolar concentration of volatile anesthesia. *Anesthesiology* 116: 1195-203.
- Scheer BV, Perel A, Pfeiffer UJ (2002) Clinical review: complications and risk factors of peripheral arterial catheters used for haemodynamic monitoring in anaesthesia and intensive care medicine. *Critical Care* 6: 1.
- Bedford RF, Wollman H (1973) Complications of percutaneous radial-artery cannulation: an objective prospective study in man. *Anesthesiology* 38: 228-236. [[Crossref](#)]
- Valentine RJ, Modrall JG, Clagett GP (2005) Hand ischemia after radial artery cannulation. *J Am Coll Surg* 201: 18-22. [[Crossref](#)]
- Türker T, Capdarest-Arest N (2014) Acute hand ischemia after radial artery cannulation resulting in amputation. *Chir Main* 33: 299-302. [[Crossref](#)]
- Mangar D, Laborde RS, Vu DN (1993) Delayed ischaemia of the hand necessitating amputation after radial artery cannulation. *Can J Anaesth* 40: 247-250. [[Crossref](#)]
- Kerr CD and Duffey TP (1988) Traumatic false aneurysm of the radial artery. *J Trauma* 28: 1603-1604.
- Turowski GA, Amjadi N, Sterling A, Thomson JG (1997) Aneurysm of the radial artery following blunt trauma to the wrist. *Ann Plast Surg* 38: 527-530. [[Crossref](#)]
- Kennedy AM, Grocott M, Schwartz MS, Modarres H, Scott M, Schon F, et al. (1997) Median nerve injury: an underrecognised complication of brachial artery cardiac catheterisation. *J Neurol Neurosurg Psychiatry* 63: 542-546. [[Crossref](#)]
- Sen S, Chini EN, Brown MJ (2005) Complications after unintentional intra-arterial injection of drugs: risks, outcomes, and management strategies. *Mayo Clin Proc* 80: 783-95.
- Garg K, Howell BW, Saltzberg SS, Berland TL, Mussa FF, et al. (2013) Open surgical management of complications from indwelling radial artery catheters. *J Vasc Surg* 58: 1325-1330. [[Crossref](#)]
- Low LL, Harrington GR, Stoltzfus DP (1995) The effect of arterial lines on blood-drawing practices and costs in intensive care units. *Chest* 108: 216-219. [[Crossref](#)]
- Smoller BR, Kruskall MS (1986) Phlebotomy for diagnostic laboratory tests in adults. *N Engl J Med* 314: 1233-1235. [[Crossref](#)]
- Gershengorn HB, Iwashyna TJ, Cooke CR, Scales DC, Kahn JM, et al. (2012) Variation in use of intensive care for adults with diabetic ketoacidosis. *Crit Care Med* 40: 1-15. [[Crossref](#)]