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Essay

Radial artery catheterism for invasive monitoring: Preventing complications, a challenge in anesthesia[☆]

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ABSTRACT

Introduction: Radial artery line placement is a common intervention in anesthesia. There is a sensation of false safety generated by the relatively low complication incidence. Identification of the primary association factors and controversies on the matter are key for prevention of complications.

Methods: We present the case of a female patient who suffered permanent ischemia in her hand after inserting a catheter in the radial artery. A reflexive review of the literature on risk factors and controversies on interventions that have been implemented is included.

Results: Placing a line in the radial artery may cause permanent ischemic injuries in as much as 0.09% of cases. 38% of cases develop thrombosis with the procedure, the risk of thrombosis increases over time and remains even after removing the cannula. The Allen test has shown to be a poor predictor of ischemic lesions. Age, use of tobacco, diabetes, renal failure and arterial hypertension are all risk factors for radial artery atheromatosis. Other elements such as the size and the material the catheter is made of, have also been related to the risk of complications. Infusions through the catheter remain a controversy. Ultrasound guides for catheterism eases the procedure.

Conclusions: This procedure is definitely not without risks. Even though many factors have been carefully documented they cannot be fully controlled and interventions aimed at prevention have not been proven to be effective.

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Cateterismo de la arteria radial para monitorización invasiva: evitar las complicaciones, un reto en anestesia

RESUMEN

Introducción: La canalización de la arteria radial es una intervención común en anestesia. La falsa sensación de seguridad en su uso proviene de la relativa escasa frecuencia de complicaciones. Identificar los principales factores asociados y las controversias aún existentes son elementos esenciales en el desafío de evitar complicaciones.

Método: Se presenta el caso de una mujer llevada a cirugía que presentó lesión isquémica permanente la mano después de la inserción de un catéter en la arteria radial. Se realiza

Palabras clave:

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una revisión reflexiva de la literatura sobre los factores de riesgo y las controversias sobre las intervenciones que han sido implementadas para prevenir las complicaciones.

Resultados: La canalización de la arteria radial puede generar de lesiones isquémicas permanentes hasta en un 0,09%. Un 38% de los casos presenta trombosis con la canalización, el riesgo aumenta con el tiempo de canalización y permanece aun después de la decanulación. El test de Allen ha demostrado no ser adecuado para predecir lesiones isquémicas. Factores como la edad, tabaquismo, diabetes mellitus, insuficiencia renal e hipertensión arterial son reconocidos como riesgo para ateromatosis de la arterial radial. Otros elementos como el tamaño y material del catéter han sido asociados con el riesgo de complicaciones. Las infusiones a través del catéter permanecen en controversia y la canalización guiada con ultrasonido solo facilita el procedimiento.

Conclusiones: Definitivamente este procedimiento no está exento de riesgos y aunque muchos factores han sido claramente documentados no es posible controlarlos todos y las intervenciones dirigidas a prevenirlas no han demostrado ser eficaces.

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A 31-year-old female patient with a diagnosis of autoimmune polyglandular syndrome, hypothyroidism, insulin-dependant diabetes, stage 5 chronic renal failure and hypertension was hospitalized for renal and pancreatic transplant. Intravenous anesthesia was induced and maintained with balanced anesthesia. Invasive monitoring was carried out through a left central venous catheter, the left radial artery was channeled with a No. 20 angiocat. After several attempts, heparin infusion began at 2 U/ml. The procedure did not require any vasoactive treatment. After a 6 h long surgery, the patient was extubated and transferred to the Intensive Care Unit, where the arterial catheter was removed 24 h later. At the third day of postoperative care, the patient claimed to have pain in her left middle finger and on the fourth day, cyanosis and coldness were found in her second and third fingers, as well as delayed capillary refill with symmetrical radial pulses. Initial management was carried out with hydromorphone and pain control was suboptimal, so left stellate ganglion blocking was carried out on the eighth day. The patient reported partial pain reduction with no other clinical changes of the ischemic event. A left upper limb arterial Doppler ultrasound revealed radial artery diameter reduction with laminar flow. The transesophageal echocardiogram discarded the possibility of a cardioembolic origin. The vascular surgery service indicated observational management, non-fractionated heparin anticoagulation and calcium antagonists. Opioid and gabapentin were prescribed for pain management at the Pain Management Clinic. On the 14th, stellate ganglion blocking was carried out once again and showed no improvement. The injury evolved into a necrosis which extended up to the proximal phalanx of the left middle finger. A month later, the patient finally required amputation.

Placing intra-arterial catheters for invasive monitoring of the blood pressure is a common intervention in anesthesia with clear indications, such as the need for real-time, continuous blood pressure monitoring, pharmacologic or mechanical cardiovascular management, multiple blood sample taking, inability to indirectly determine the blood pressure, wave and volume response information derived from systolic pressure or pulse pressure variability.¹ The radial artery is the place of choice because of its accessibility, simplicity and management. Although fairly uncommon, most

complications of arterial line placement are asymptomatic solved spontaneously.² Permanent ischemic hand injuries have been reported to occur in 0.09% of cases, and others such as sepsis (0.13%), local infection (0.72%), pseudoaneurysms (0.09%), hematomas (14%) and bleeding (0.5%).³

Bedford and Wollman⁴ reported thrombosis in 38.5% after radial artery placement, with Doppler ultrasound demonstrated preserved distal blood flow in 92.5% of cases and palpable radial pulse in 72.5%, secondary to ulnar artery collateral circulation. They also found a relation between thrombosis and arterial line placement time over 20 h. Thrombosis and vasospasm events were identified even after removing the cannula, where only 10% of cases showed clinical signs of vascular compromise that remitted seven days later. The arterial permeability recovery period lasted as much as 75 days. On the other hand, Slogoff et al.⁵ found that more than 25% of patients had partial or total occlusion of the radial artery, but none showed clinical signs of ischemia, which have been reported to appear lately, as in this case. These signs may coexist with radial pulse, so diagnosis may require diagnostic aids such as Doppler US and angiography.

The high incidence of blood flow compromise detected with Doppler ultrasound after radial artery line placement is acknowledged; so a search for predicting factors for complications is in progress. The Allen test has been employed for assessing the collateral hand circulation quality during temporary occlusion for predicting ischemic injury should circulation be interrupted permanently. In a trial by Slogoff, only 3.9% of cases had an abnormal Allen test and none of them showed any complications after line placement. Such results suggest the Allen test is not a reliable predicting test in absence of vascular disease. Barone and Madlinger⁶ carried out a review of the literature and concluded that there is no consensus on the parameters of an abnormal Allen test or its significance; therefore it is not an adequate method for prediction of line placement complications.

Trials in patients who have undergone myocardial revascularization have shown that age above 50, use of tobacco, arterial hypertension, diabetes and kidney failure are the factors with highest association with hyperplasia, calcification and atheromatosis of the radial artery.⁷ Even though this is the case of a young patient, her comorbidities as a

whole were all risk factors concerning invasive monitoring complications.

The risk factors associated to arterial line placement complications are: prolonged time with an arterial line in place (more than 20 h), catheter manufacturing material, catheter size, closed-tip catheter, small wrist diameter, arterial hypotension, hypercoagulability, use of vasoactive drugs, autoimmune disease, diabetes, female gender, age 65 or older and hematoma in the line placement site.^{3,8} Generally, Teflon catheters are associated to lower incidence of thrombosis when compared to polypropylene catheters.⁹ In 1977, Bedford¹⁰ found a greater rate of arterial thrombosis when using 18 G catheters compared to 20 G catheters (36% vs. 8% respectively) and demonstrated a direct relation between thrombus formation and artery diameter (greater for artery diameters under 2 mm) and longer replacement time in small vessels. This finding is explained by the greater transversal area of 18 G catheters compared to 20 G catheters. The puncture method (direct or transfixing) has not been associated to an increased risk of thrombosis and replacement of arterial lines does not increase occlusion frequency.⁸ On the other hand, guided insertion arterial catheters with modified Seldinger technique were expected to carry out the procedure with a higher success rate compared to conventional methods. However, trials have shown that there is no difference in success rates, total procedure times or complication rates.¹¹⁻¹³

Infusions through arterial catheters are another consideration for the risk of complications. Although some trials on the effect of heparin infusions at 4 U/ml doses have been proven more effective than normal serum infusions at 0.9% for catheter permeability maintenance and reducing thrombus formation for as much as 96 h,¹⁴ other researches with lower heparin doses (as low as 1 U/ml) showed that there was no significant difference in catheter duration and functionality.¹⁵ In addition, it has been proven that even at low doses patients may present partial thromboplastin time alterations.¹⁶

Ultrasound guided puncture is a new strategy implemented for increasing success rates of arterial line placement, which allows detecting, locating and determining the permeability of the artery. A study that compared ultrasound guided catheterization and conventional arterial line placement showed that the success rate of the first placement attempt was higher with US compared to the traditional palpation method (62% vs. 34%), and the total number of attempts was lower with US guided line placement.¹⁷ In spite of these findings, the use of US for arterial line placement is not recommended as a routine procedure, it is considered to be more effective as a recovery technique.¹⁸

Even though anatomical variants of the radial artery have been associated to the appearance of ischemic complications after catheterization, as much as 30% of individuals have been reported to have an anomalous origin or course. They are generally less significant in the distal portion of the artery, where the catheter is usually placed.¹⁹ Several different studies have shown a complete superficial palmar arc in more than 80% of the patients' hands and deep palmar arc in 90-95%.²⁰ Valentine et al.²¹ found no cases of significant arterial anomalies in their review of ischemic events secondary to catheterization during a 5 year period. The common finding was the presence of arterial thrombosis and hand

circulation vasospasm. Doppler US in our patient revealed a reduced diameter of the radial artery, very suggestive of vasospasm. For this reason, the treatment was aimed towards vasodilation, such as stellate ganglion blocking and calcium antagonist drugs. The treatment of ischemic complications of arterial line placement is controversial and must include individualized management, given that the cause of ischemia is not fully understood. Even though local injuries may induce thrombosis and/or vasospasm and consequently reducing blood flow, collateral circulation should be able to compensate. A current theory is that an embolic phenomenon that compromises collateral circulation or the digital arteries could be the cause of distal ischemia and residual injuries in surgical interventions. In case this complication appeared, the catheter should be removed and patients with symptomatic vasospasm and thrombosis should be treated with vasodilation and anticoagulation therapy. The same measures apply to more severe cases with blood flow reduction, ischemia with thrombectomy and radial artery repair.^{9,10,22,23}

Since Peterson's first description in 1949,²⁴ the use of arterial line placement for invasive monitoring has been increased because of the valuable information it provides and its simplicity. Nevertheless, a sense of false safety has emerged due to the low frequency of complications. In time, some factors associated to complications have been identified and interventions have been employed in their prevention. Yet controversies on their effectiveness remain. It is necessary to consider that this procedure may cause permanent repercussions and the attending physician must be aware of all the elements involved in such complications.

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Conflicts of interest

None declared.

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