Perspective

Central versus femoral cannulation during minimally invasive aortic valve replacement

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Minimally invasive aortic valve replacement (AVR) is rapidly becoming the preferred approach for aortic valve procedures in most centers worldwide. While femoral artery cannulation is still the most frequently used form of arterial perfusion strategy during less invasive AVR, some recent studies have showed a possible connection between retrograde perfusion and cerebral complications. In this article, we discuss the possible advantages of central aortic cannulation during right minimally invasive AVR and provide some technical aspects for a safe and efficient cannulation of the ascending aorta through a right minithoracotomy.

Keywords: Aortic valve; minimally invasive cardiac surgery; cardiopulmonary bypass

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Perspective

In recent years, minimally invasive valve techniques have become the preferred approach for aortic valve replacement (AVR) in most centers worldwide. In particular, the upper partial sternotomy and the right minithoracotomy are the two most used incisions for minimally invasive AVR. This approach has been driven by potential advantages of reduced pain, shorter hospital stays, faster return to normal activities, superior cosmesis, and potential cost savings. The transition towards less invasive approach has been characterized by the development of new, innovative arterial and venous cannulation techniques. Two perfusion strategies are available for minimally invasive AVR: the retrograde route with femoral artery cannulation and the antegrade route with direct ascending aorta cannulation. While ministernotomy approaches provide standard access to the ascending aorta, right minithoracotomy incisions can limit exposure of the ascending aorta, requiring extensive modification of the surgical and perfusional strategy. Since the early description by Benetti *et al.*, the right minithoracotomy AVR is predominantly performed with femoro-femoral bypass (1). While good results have been reported with femoral artery cannulation, in some instances, retrograde perfusion may lead to related complications including infection, lymphoid fistula, arterial wall dissection, and distal limb ischemia (2). Moreover, the possible association between retrograde perfusion and cerebral or vascular complications have been explored in several retrospective studies of minimally invasive valve surgery (3-5). In these studies, authors have raised the suspicion that retrograde perfusion strategy during minimally invasive procedures can be associated with an increased risk of neurological complications when compared with antegrade perfusion.

The group from New York University (NYU) have recently published two interesting studies on this issue. In 2012, they presented an analysis of 3,180 isolated, non-reoperative mitral and aortic valve procedures (72% performed with a minimally invasive approach) (3). Multivariate analysis showed that increased stroke risk was associated with an atherosclerotic aorta, cerebrovascular disease, emergent operation, ejection fraction <30% or retrograde perfusion ($P<0.05$ for each), but not with incision location ($P=0.82$). Subsequently, the same group presented a focused report on a more homogeneous subset of 1,282 first-time, isolated mitral valve operations performed through a right anterior mini-thoracotomy showing that the only significant risk factor interaction for neurologic complication identified was the use of retrograde

perfusion in patients with high-risk comorbidities, such as peripheral vascular disease, cerebrovascular disease, atherosclerotic aortas or dialysis dependence (4). In 2013, our group has carried out a similar analysis on 1,280 non-reoperative minimally invasive mitral valve surgery, and our results reconfirm the negative impact of retrograde arterial cannulation on neurological outcome (5). In particular, we have found a 2-fold increase in the risk of stroke for patients undergoing minimally invasive mitral procedure with retrograde perfusion. Of particular interest is the fact that in all these studies, the association of retrograde perfusion and neurologic complications was not significant in younger patients. While one may argue that all of the previous studies are mainly focused on minimally invasive mitral procedures and not on minimally invasive AVR, it is clear that an association between retrograde arterial perfusion (RAP) and stroke exists and that this association is particularly strong in older patients with atherosclerotic burden disease. For these reasons, considering that patients with aortic stenosis are usually older and with significant comorbidities, similar or even worse results may be expected in patients undergoing minimally invasive AVR with femoral artery cannulation. In our opinion, antegrade perfusion through the ascending aorta has several advantages when compared to femoral artery cannulation. Antegrade perfusion is more "physiological", and dramatically reduces the risk of plaque embolization, iatrogenic aortic dissection and avoids complications related to groin incisions. Additionally, routine cannulation of the ascending aorta expands the suitability of minimally invasive AVR to include those patients who have an absolute contraindication to femoral artery cannulation. Nevertheless, despite these potential benefits, many surgeons are still reluctant to perform central aortic cannulation through a small right thoracotomy. The reasons for this reluctance are multifactorial, including the perception that cannulation the ascending aorta is a challenging procedure, especially due to the learning curve and that eventual bleeding at the cannulation site may translate into a deleterious outcome.

Our surgical technique

During these years, we have developed several tricks that can help the surgeon safely cannulate the ascending aorta. It is very important to retract the pericardium and to expose the aorta until the origin of the innominate artery. This allows the ascending aorta to come right forward and to obtain a better exposure. Two concentric 2-0 polyester purse string sutures are placed on the anterolateral aspect of the ascending aorta with second purse string reinforced with two pledgets. This time, pharmacologic induction of hypotension is mandatory. The cannulation site is generally chosen to be as high as possible, but in the case of suboptimal exposure it can be sufficient that the cannulation site stays one cm above the cross-clamp level. Before inserting the arterial cannula, we prefer to cannulate the femoral vein in effort to have the chance to reinfuse the patient. Subsequently, direct ascending aorta cannulation is performed under direct vision with induced hypotension (systemic arterial pressure <90 mmHg). The lungs must be deflated prior to aortic cannulation. The adventitia is prepared with scissors and the aortic cannula is advanced into the aorta. During cannula insertion, the aorta can be kept steady using locking forceps to reduce physiological motion. After cannula deployment and while the assistant holds the cannula, the first operator must secure the cannula with two tourniquets using a silk suture. However, this can be difficult in cases of a deep chest and distant cannulation sites. For these particular situations, a silk suture previously placed through the tourniquet can facilitate knotting into the chest. Our protocol for aortic cannula removal consists of first removing the arterial cannula under systemic hypotension, leaving in place the femoral vein cannula to fill patients with residual blood in the cardiotomy. This may also help in case of bleeding from the arterial cannulation site. Finally the femoral vein cannula is removed. In our center, we have started a minimally invasive AVR program in 2003 and since then, 587 patients have undergone right minithoracotomy AVR. Our current clinical practice attempts to restrict RAP to those surgical scenarios where there is very limited central aortic access, such as patients with small ascending aorta or calcification at the cannulation site. We have performed direct ascending aorta cannulation for AVR on 521 patients in total. Our rate of stroke was 1.3% and in-hospital mortality was 1.1%. No postoperative aortic dissection was observed and intraoperative conversion to sternotomy for bleeding at the cannulation site was necessary in one patient.

Conclusions

In conclusion, despite central aortic cannulation being viewed as more challenging than femoral artery cannulation, it can be performed safely with a very low incidence of neurological and vascular complications. It can help to minimize risks associated with retrograde perfusion and can

expand minimally invasive AVR even to those patients who are deemed not suitable for retrograde perfusion.

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