

Reply to Del Giglio, Tamagnini, Biondi and Di Mauro

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August 28, 2020

LETTER TO THE EDITOR RESPONSE

We thank Dr. Del Giglio et al. for their comments. As it was stated in our paper¹, our primary goal was to describe our approach and procedural details to MIAVR by way of RALT. For further reading we would also like to draw attention to our video tutorial regarding RALT-MIAVR². Nevertheless, we would like to congratulate Dr. Del Giglio and his colleagues for their significant contribution to the field of minimally invasive aortic valve treatment^{3 4 56}.

We completely agree with Dr. Del Giglio et al. that our statement regarding preoperative CT-scanning being *mandatory* is somehow misleading. However, other colleagues also consider a preoperative CT scan obligatory for RALT-MIAVR⁷ providing important additional information over TEE⁸. Three-dimensional reconstructed multidetector CT images allow virtual planning of the exposure leading to a reduced ischemia time and a reduced conversion rate⁹. It has also been shown that systematic preoperative CT screening in MIMVS is associated with lower risk of postoperative stroke and a trend towards lower operative mortality¹⁰. Although we agree with Dr. Del Giglio et al. that CT assessment is helpful at the beginning, it remains accommodating throughout the complete learning curve and thereafter. Andre Plass et al.¹¹ wrote that preoperative planning with multi-slice CT leads to an improved mental preparation and to an efficient and accurate surgical strategy including the choice of the optimal ICS. In their *Letter to the Editor*, Dr. Del Giglio et al. wrote that surgical access site selection does not require a CT scan, that the third ICS is the right one in most cases and that the surgeon could easily change to the second ICS from the same skin incision. We agree that changing ICS is easily possible, yet it also means added surgical damage and this should be avoided whenever possible. An automated method determining the closest ICS to the STJ as the optimal incision location for MIAVR has already been introduced¹². A novel MIAVR tool that combines 3D imaging with quantitative planning measures has also been described¹³. The access angle is strongly associated with procedure complexity¹³ and with CPB time, x-clamping time and access difficulty¹³. Moodley et al.¹⁴ reported that mandatory CT-screening of the chest, abdomen and pelvis revealed significant subclinical aorto-iliac atherosclerosis resulting in a change in surgical approach in 21% of asymptomatic or mildly symptomatic patients scheduled for MIMVS (Figures 1 through 3). Regarding the interpreting and reconstructing of CT scans we agree with Dr. Del Giglio et al. that this means technological skills, time and financial resources. But with transcatheter cardiac procedures becoming more popular, it is important for the society of surgeons to master all aspects of case planning, which not only includes analysis and measurement but also the reconstruction of CT scans. As pointed out by Dr. Del Giglio et al. MIAVR has to reproduce the gold-standard conventional procedure in terms of safety, effectiveness and especially operative times through a respectful approach; yet in our opinion, preoperative non-invasive CTA screening in every patient scheduled for a RALT-MIAVR procedure remains crucial.

In view of truly MIAVR, we believe that arterial and venous central cannulation both at the same time through the same incision does not reduce surgical trauma and could lead to central working port obstruc-

tion or significant narrowing. We believe that peripheral cannulation of the femoral vasculature is as safe and reproducible as central cannulation if the individualized anatomical characteristics allow for it. When carrying out percutaneous femoral arterial cannulation, we never perform a blind puncture of the femoral vessels. We prefer to have zoomed-in snapshots from our reconstructed CT scans on display in the OR to accurately puncture the CFA as displayed in figures 1 and 2 for example. Data set published by Eugene A. Grossi et al.¹⁵, suggest that if in older patients a femoral perfusion technique is chosen, preoperative evaluation of the aorta and distal vasculature would demonstrate that a given patient would not be at increased neurological risk¹⁵. This would include CTA of the aorta with runoff and TEE evaluation of the descending aorta¹⁵. They also published that RAP is associated with an increased risk of stroke in patients with severe PVD and should be reserved for selected patients without significant atherosclerosis. Such a thoughtful screening approach has been used also by Murphy and associates¹⁶ in robotic mitral valve surgery for example¹⁵. M. Murzi et al.¹⁷ were able to show that the use of RAP in MIMVS was associated with a higher incidence of neurological complications in older patients (>70 years old) with atherosclerotic burden compared with AAP. Still, their study had several limitations as it was based on a retrospective analysis of patients undergoing consecutive MIMVS over a 12-year period and potential bias might have been present¹⁷. The observational retrospective analysis of K. Bedeir et al.¹⁸ proved that femoral artery cannulation may be associated with increased stroke rates in isolated mitral valve surgery and that antegrade arterial cannulation (direct aortic or axillary cannulation (figure 2)) may be preferable in MIAVR. However, their consensus was that these preliminary data should trigger a larger-scale randomized prospective trial to confirm or refute these findings¹⁸.

In pursuance of reducing hemolysis during CPB¹⁹, body temperature is maintained at around 34°C and DO₂-guidance (goal-directed-perfusion). This is also helpful in regard to optimal venous drainage as it allows the surgeon^{1,2}, to safely reduce the calculated pump flow. Furthermore, we augment venous drainage with the use of vacuum assistance (-20 to -35 mmHg) to decompress the right heart¹. On one hand, R.K. Mathews et al.²⁰ were not able to show a significant increase in hemolysis or sub-lethal red blood cell membrane damage, associated with the use of augmented venous drainage. On the other hand, D. Goksedef et al.²¹ showed that based on their results, negative suction at 80 mmHg may cause greater hemolysis than non-vacuum-assisted drainage or vacuum-assisted drainage at 40 mmHg. For this reason, we try to keep the vacuum assistance between 0 and -35 mmHg. Besides, it has been proved that application of a controlled, negative low pressure to the venous return does not cause hemolysis worse than gravitational CPB²².

At last, Dr. Del Giglio et al. reported concerns about our SLL-PEEP (maximum 20 cmH₂O) technique to inflate the left lung which pushes the aorta towards the surgical access. It is true that increased airway pressure or the application of high tidal volumes may cause damage or disruption of alveolar epithelial cells, by generating transpulmonary pressures that exceed the elastic properties of the lung parenchyma above its resting volume²³. It has been demonstrated that the duration of mechanical stress defined as the stress versus time product affects the development of pulmonary inflammatory response²³. However, in a recent meta-analysis of postoperative pulmonary complications after intraoperative ventilation, only a high driving pressure was associated with an increased incidence²⁴. Therefore, it is highly unlikely that in an apneic patient on CPB, the elevation of the PEEP-level of 5 to 20 cmH₂O without a resulting change of driving pressure has any significant negative effect on pulmonary outcome.

In summary, we agree with the important points addressed by Del Giglio et al. Central cannulation and its AAP is possible without the need for preoperative CT scanning. However, for the sake of MIAVR (no rib resection, no IMA sacrifice) we prefer peripheral percutaneous cannulation. For such a RAP cannulation strategy, there is sufficient convincing literature that preoperative CTA scanning should be considered.

Funding statements

Not applicable.

Authors' contributions

All authors made contributions to the development of this response to the letter to the editor, contributed

important intellectual content, and reviewed and approved the final version of the manuscript.

FIGURE LEGEND

Figure 1: Iliofemoral vessels evaluation. Bilateral reconstructions and snake view of the iliofemoral vessels and descending abdominal aorta. This patient had heavy calcifications of the more distal vessels and so an alternative cannulation site for AAP needed to be found. A cannula with a 6 mm diameter would not even fit into the common femoral artery and this could lead to obstruction and ipsilateral limb ischemia. We also believe that cannulation and RAP of the femoral vessels in a patient with such anatomical characteristics would distinctly increase the risk of perioperative stroke and dissection.

Figure 2: Evaluation of the right axillary artery as cannulation site for antegrade arterial perfusion. If cannulation of the femoral vessels is not an option during case planning for RALT-MIAVR, the right axillary artery should be considered as an alternative cannulation site. In this case the right axillary artery presented with a diameter of 7 mm without calcifications and atherosclerotic burden.

Figure 3: RALT-MIAVR case awareness. **A)** Heavily calcified ascending aorta and aortic arch, not suited for central cross-clamping. **B)** Snake view of the right iliofemoral and descending abdominal aortic axis of two different patients. The left picture showing a chronic type B dissection and aneurysmal aortic disease. The picture on the right side outlines atherosclerotic disease and soft plaque buildup. A RAP strategy in these patients would not be suitable. **C)** Although referred to our institution for RALT-MIAVR, we conducted a TAx-TAVI in this patient. The iliofemoral vessels and abdominal aorta portrayed too much atherosclerosis and analysis of the aortic annulus using 3mensio software showed a rather small annulus with low implantation of the right coronary ostium (1cm). **D)** Examination of the anatomy of the aortic root revealed an aberrant RCx. **E)** The hockey-puck perspective of the aortic valve exhibits extensive calcification of the leaflets, the annulus even reaching into the LVOT. In this patient MAC of the mitral valve was also found. The total calcium scoring in this patient was 1789.2 mm³. **F)** Three-dimensional reconstructions of the bony structures of the thoracic cage allows the surgeon to precisely select the right ICS as his main working port for RALT-MIAVR. In this particular case the third ICS (green dotted line) would be the optimal access site, whereas the second ICS (red dotted line) would be too cranial.

FIGURES

Figure 1:

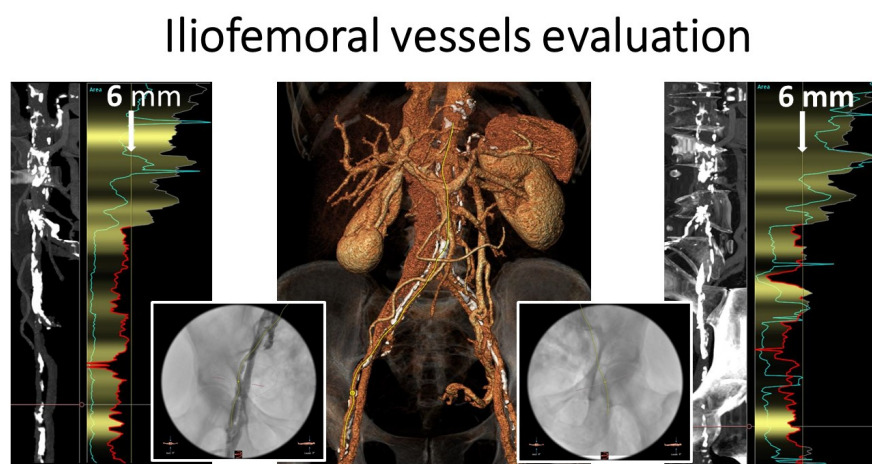


Figure 2:

Access evaluation: right axillary artery cannulation

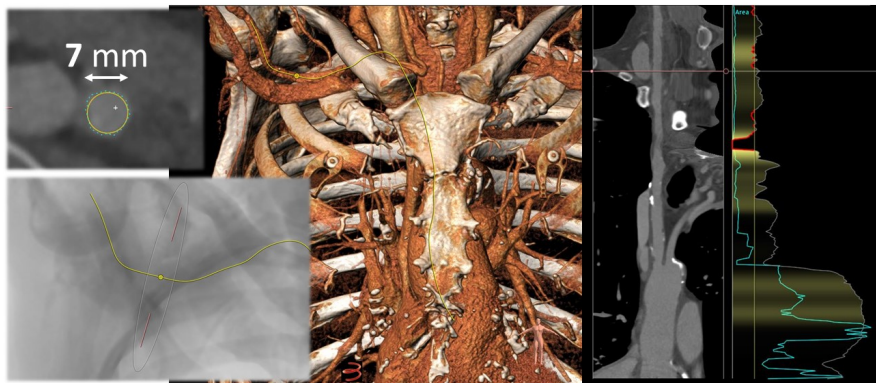
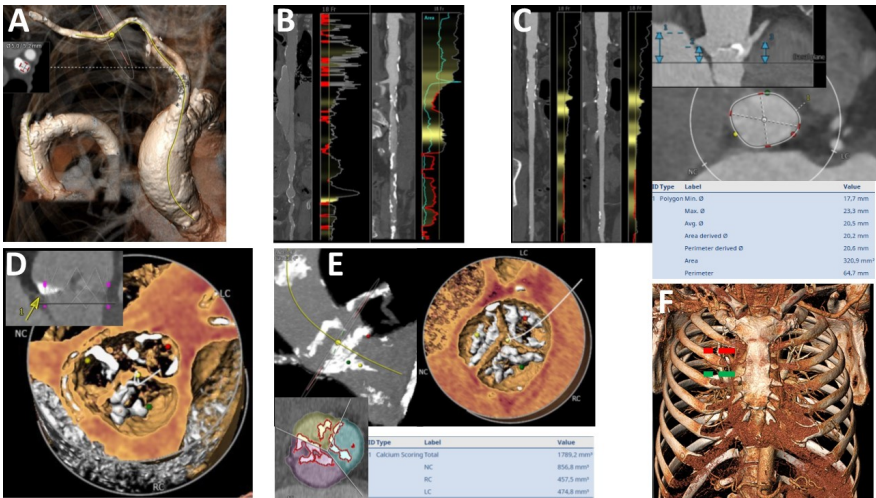


Figure 3:



ABBREVIATIONS

MAVR	Minimally invasive aortic valve replacement
RALT	Right anterolateral thoracotomy
MMCTS	Multimedia manual of cardio-thoracic surgery
CT	Computed tomography
CTA	Computed tomography angiography
CAD	Coronary artery disease
CAG	Coronary angiography
TEE	Transesophageal echocardiography
MIMVS	Minimally invasive mitral valve surgery
ICS	Intercostal space
STJ	Sinotubular junction
CPB	Cardiopulmonary bypass
X-clamping	Aortic cross-clamping

MIAVR	Minimally invasive aortic valve replacement
RAP	Retrograde arterial perfusion
AAP	Antegrade arterial perfusion
RCT	Randomized controlled trial
CFA	Common femoral artery
PVD	Peripheral vascular disease
SLL	Single left lung
PEEP	Positive end expiratory pressure
OR	Operating room
TAx	Transaxillary
TAVI	Transcatheter aortic valve implantation
RCx	Circumflex coronary artery
LVOT	Left ventricular outflow tract
MAC	Major annular calcification of the mitral valve
IMA	Internal mammary artery

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