Title: Right-sided minimally invasive direct coronary artery bypass: preoperative planning and surgical technique

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Central Picture Legend

We present our approach to the r-MIDCAB technique
Central Message
Right-sided minimally invasive direct coronary artery bypass (r-MIDCAB) can offer an attractive minimally invasive alternative to full sternotomy in isolated complex right coronary artery disease or in anomalous RCA. We present our approach to the r-MIDCAB technique (Central picture).

Introduction
Left-sided minimally invasive direct coronary artery bypass (MIDCAB) has gained wide-spread popularity since its introduction in the 1990s for the treatment of isolated left anterior descending artery (LAD) stenosis or as part of a hybrid approach in multi-vessel coronary artery disease (CAD).\textsuperscript{1,2} In isolated complex right coronary artery (RCA) disease or in anomalous RCA (ARCA), right-sided minimally invasive coronary artery bypass (r-MIDCAB) can offer an attractive minimally invasive alternative to full sternotomy.\textsuperscript{3} We aim to present our approach to r-MIDCAB using right internal thoracic artery (RITA) to RCA, based on our experience with nearly 20 cases. Informed consent for the publication of the study data was obtained from patient and no institutional review board approval is needed for this report according to the German law.

Preoperative assessment
In addition to the routine preoperative diagnostic workup, consisting of coronary angiogram, transthoracic echocardiography and chest x-ray, we perform a CT scan and analyze it using 3mensio Structural Heart software (3mensio Medical Imaging; Bilthoven, The Netherlands), which is crucial to determine the optimal intercostal space (ICS) and accessibility of RCA. The zone 3 is generally the most distal part of the RCA for comfortable anastomosis. Sometimes posterior descending artery can be reached and anastomosed; however, there is no guarantee, so we would tend to refrain from r-MIDCAB in these cases.
Surgical technique

As in left-sided MIDCAB, the use of unilateral lung ventilation is employed in all patients through either double-lumen tracheal intubation or selective endoluminal blockage guided by bronchoscopy. Transesophageal echocardiography is standard across all cases. Patient is put in the supine position, with a 30° elevation of the chest on the right side facilitated by the placement of a soft pillow beneath the scapula (Figure 1).

The surgical procedure is carried out through a 5-6 cm long right anterior minithoracotomy (Figure 2). The RITA is harvested under direct vision using a Hauser retractor (B.Braun/Aesculap AG; Melsungen, Germany) in a skeletonized technique using a regular diathermal blade and hemostatic clips. It is paramount to retract the ribs gradually in order to avoid rib fractures (Supplemental Figure 1). Unlike the left-sided MIDCAB, where the 4th ICS provides optimal access for left internal thoracic artery (LITA) harvesting almost in all cases, in the majority of r-MIDCAB, the 5th ICS is utilized to maximize the length of the RITA. The length of the harvested RITA corresponds nearly to the length achieved through a median sternotomy, sometimes even longer. Proximal harvesting of the RITA extends up to the 1st ICS, close to the subclavian vein, while distal harvesting reaches until the bifurcation. Systemic heparin (1 mg/kg) is administered to achieve an activated clotting time of at least 300 seconds during the surgery. Subsequently, the RITA is divided, and the distal end is secured to the skin level using a 6-0 polypropylene suture.

The pericardium is then opened ventrally over the right atrium, which is retracted by pericardial stay sutures for ventral luxation of the heart. A reusable mechanical MIDCAB stabilizer (Fehling Instruments; Karlstein, Germany) facilitates stabilization of the targeted area for anastomosis to the RCA. Proximal snaring of the RCA is achieved using a silastic hollow vessel loop with a blunt-tipped needle (Ethiloop; ETHICON, NJ, USA). The anastomosis is executed in a standard end-to-side off-pump fashion using 8-0 polypropylene sutures, with the routine incorporation of a coronary shunt (Clearview; Medtronic; Dublin,
Ireland), and a CO₂ blower (Accumist Blower/Mister; Medtronic; Dublin, Ireland) for optimal visualization of the operative field (Video 1).

Following the completion of the anastomosis, the patency of the bypass is confirmed through transit time flow measurement using the MiraQ Cardiac system (Medistim ASA; Oslo, Norway). The pericardium is closed, allowing unobstructed course of RITA into the pericardium through attaching the fatty pad margin to the medial portion of the pericardium at the basal portion of the pericardiotomy. It is important to cover the anastomosis site to protect it from lung rubbing, which can cause kinking or rotation. A 28F chest drain is inserted into the right pleural cavity through the 6th ICS. The minithoracotomy closure is accomplished using a resorbable polyglyactin 2-0 Z-suture of the ribs, followed by layered wound closure.

Postoperative pain management is addressed through the administration of periosteal and intramuscular 0.7% bupivacaine.

**Postoperative course**

The majority of patients undergoes extubation in the operating room. Subsequently, they are promptly transitioned to the intensive or intermediate care unit for further monitoring and care.

Initiation of postoperative pharmacotherapy includes the administration of acetylsalicylic acid at a daily dose of 100 mg on the first postoperative day (lifelong), and additionally a P2Y12-receptor antagonist on the second postoperative day (Clopidogrel or Ticagrelor) for 6 months postoperatively.

**Discussion**

Right-sided MIDCAB has proofed its feasibility and safety in isolated complex RCA disease or in ARCA, as published in our initial experience with 11 cases. In the meantime, we have successfully operated on another 7 patients. In our opinion, minimally invasive RITA harvesting and its anastomosis to RCA in zone 2 is similarly demanding as in regular left-
sided MIDCAB. More distal anastomosis may be more challenging and requires sometimes a
diaphragmic traction suture in the tendinous center for luxation of the heart and better
exposure. The patency of the RITA graft remains excellent with up to 90% at 10 years based
on angiographic studies. Therefore, r-MIDCAB offers an attractive minimally invasive
alternative for selected patients in single vessel disease with respect to the location of the
stenosis.
REFERENCES


LEGENDS

Central picture: Postoperative computer tomographic scan postprocessed in 3mensio Structural Heart (3mensio Medical Imaging; Bilthoven; The Netherlands) showing patent right internal mammary artery in situ to the right coronary artery at zone three.

Figure 1: Intraoperative image showing palpation of the 5th intercostal space.

Figure 2: Intraoperative picture of the surgical setting for preparation of the right internal mammary artery after minithoracotomy at the 5th intercostal space before inserting the rib lifting retractor.

Supplemental Figure 1: Intraoperative picture of the surgical setting for preparation of the right internal mammary artery after placement of the rib lifting retractor in the 5th intercostal space.

Video legend: Intraoperative video showing harvested right internal thoracic artery (RITA) and execution of the anastomosis of RITA to distal right coronary artery in a standard end-to-side off-pump fashion.