Recommendations and Best Practices for Radial Artery Use in Coronary Artery Bypass Grafting

BACKGROUND

Evidence has shown that multiple arterial grafting using the internal mammary and radial arteries during coronary artery bypass surgery improves long-term survival (1). Patients receiving arterial grafts experience lower rates of recurrent angina, lower rates of myocardial infarction, and lower rates for the need for repeat revascularization. Current guidelines from U.S. and European societies encourage the use of multiple arterial grafting in patients who have anticipated long-life expectancy (2-5). This document provides consensus opinion on best practices for the use of the radial artery (**RA**) as the second arterial conduit.

PURPOSE

The MSTCVS Quality Collaborative has developed best practices with the following consensus recommendations for use of the RA in coronary artery bypass grafting. The purpose of this document is to provide guidance for radial artery use understanding deviations from best practices may be required due to specific patient situations or clinical conditions.

Preoperative Phase

1. **Patient Selection:**
   - **a) Indications:** Patients < 80 years old should be strongly considered for RA harvesting. There is no age limitation for the use of the RA in coronary artery bypass surgery.
   - **b) Relative Contraindications**
     - i. Careful consideration should be given to patients with renal disease receiving dialysis or who have the potential for future need for dialysis.
     - ii. Recent history of coronary angiography via the RA or the prolonged use of a radial arterial line are relative contraindications for use of the RA. The duration of impairments on the vasomotor function of the RA and RA diameter due to coronary angiography are not completely understood. According to certain evidence, RA endothelial and smooth muscle vasomotor function, along with luminal diameter seem to return to baseline after a three-month period [6-9]. However, there is convincing evidence of severe morphological and functional damage of the RA along its length that is not only limited to the cannulation site. Also, there is evidence of a potentially long duration of injury following catheterization with a substantial reduction in graft patency if the RA is used for a bypass conduit. Therefore, whenever possible, surgeons should give preference to using an uninstrumented RA. If limited conduit options exist and a previously instrumented RA has to be used for conduit, the surgeon should obtain a duplex study to assess the patency and diameter of the artery throughout its length and avoid the use of the distal end of the RA.
     - iii. Major arm trauma, history of arm surgery, systemic vasculitis without Raynaud's, carpal tunnel surgery, left breast/axilla surgery with lymphedema, skilled workers (i.e. musicians) are relative contraindications for use of the RA
     - iv. Autoimmune conditions such as scleroderma and rheumatoid arthritis (26)
     - v. Use of the RA in situations of mild-moderate stenosis of the coronary artery target vessel should be avoided. In several studies, a strong association has been demonstrated between the severity of the disease of the target vessel and the patency of RA grafts (10-12). Data from a large randomized clinical trial including 440 RA grafts demonstrated that occlusion was more likely to occur in those patients with a target-vessel proximal stenosis <90% (10). Furthermore, similar findings were reported in 20-year follow-up period, where 80% of cases of RA occlusion or string sign occurred in patients in whom the RA was anastomosed to native vessels with stenosis ≤90% (11). Consistent with these observations, an

analysis of angiograms of 2,127 arterial grafts identified that the degree of native coronary artery stenosis had a significant influence on arterial conduit patency with a threshold stenosis of 80% for RA conduit (12).

c) Absolute Contraindications

i. Patients with collagen vascular diseases and associated Raynaud's syndrome.
ii. Insufficient ulnar artery collateral flow evaluated with a modified Allen's test and or Barbeau test (see below).
iii. Ipsilateral arm AV Fistula

2. **Diagnostic Testing – The purpose of diagnostic testing is to assess the radial artery for collateral flow, diameter, and lack of calcification. Recommended tests below can be used individually or in combination based on the availability at the local level.**

a) Modified Allen's Test
   i. Used reliably preoperatively to assess if collateral circulation via the ulnar artery is adequate to perfuse the hand (see Appendix A).
   ii. A modified Allen's test should be repeated intraoperatively prior to harvest to confirm adequate collateral ulnar artery blood flow to the hand.

b) **If the modified Allen's test is positive (i.e., evidence of inadequate collateral ulnar artery blood flow) an additional non-invasive test (i.e. Barbeau test) is appropriate to obtain as the relative lower sensitivity of the modified Allen's test means that the RA may still be safe to harvest in many patients.** Barbeau test (pulse oximeter) can be conducted to evaluate collateral circulation (13, 14)
   i. Pulse oximeter is placed on the index finger and both the ulnar artery and RA are manually occluded.
   ii. Complete occlusion is confirmed by lack of a waveform displayed with the pulse oximeter.
   iii. The ulnar artery is then released; if the palmar arch is incomplete, the pulse oximeter waveform reflecting pulsatile flow will not be displayed. If the palmar arch is complete, a waveform on the pulse oximeter should return and the O_2 saturation by oximetry should be maintained during continued radial artery compression.
   iv. This test should then ideally be repeated with the pulse oximeter on the first digit, or thumb.

c) Vascular studies, ultrasound/doppler evaluation or RA mapping strongly considered to identify plaques or calcification.
   i. The diameter of the RA should be at least 2mm and larger than the residual diameter of the stenosed target vessel.

3. **Preoperative Care**

a) Limb alert in preoperative area
b) No arterial or venous punctures in harvest extremity
c) Inform anesthesia and operative team of probable radial artery use

Intraoperative Phase

1. **Harvesting**

a) NTG gtt @ 5mcg/min prior to incision for anti-spasm properties.
b) Milrinone may be used as an effective vasodilator for the radial artery
c) Historically, the non-dominant arm has been the preferred site for RA harvesting. However, the site with better ulnar collateral blood flow should be considered regardless of hand dominance (23).
d) There is evidence that the use of a harmonic scalpel for open RA harvesting appears superior compared to electrocautery (15.)

2. **Technique**

a) Open Technique
b) Endoscopic Technique (preferably with an arm tourniquet on stand-by)

3. **Artery Preparation**
   a) Radial Artery Solutions
      i. Verapamil 5 mg, bicarb 1 mEq/ml (8.4%) - 0.2 ml, NTG 2.5 mg, heparin 5000 units
      ii. Papaverine 60 mg is applied after the RA is harvested
      iii. Nitroglycerin alone
      iv. Note: Diltiazem and papaverine are not compatible and should not be mixed as a precipitate will result.
   b) Strongly consider a radial artery fasciotomy on the volar aspect to allow dilatation and prevent RA spasm. This is a critical component of artery preparation to ensure short-term patency. An added benefit is that this would facilitate identification of potentially avulsed branches for repair. Also, additional skeletonization for 2 cm at the distal end and 3 to 4 cm at the proximal end is recommended. This allows maximal dilatation at the anastomotic points and protects against accidental incorporation of any fibrous bands that may distort the anastomosis. Also, skeletonization theoretically enhances denervation and attenuates potential sympathetic responses and vasoconstriction.

4. **Target Vessel Selection**
   a) The best non-LAD left sided target that has a >80% stenosis
   b) Right coronary system with a >90% stenosis as long as the diameter of RA is bigger than the diameter of the residual lumen of the RAC/tributaries

5. **Proximal Anastomosis Sites (Appendix B)**
   a) Ascending Aorta – Improved patency of RA conduits with inflow from aorta compared to inflow as a composite graft from IMA has been shown[26]
   b) LITA or RITA
   c) Vein graft hood

6. **Wound Management**
   a) Closure:
      i. Only the subcutaneous and skin should be closed and rigorously avoid the closure of the muscle or fascial layers. Doing the latter can risk compartment syndrome in the forearm should bleeding occur, with possible long-term sequelae to hand function.
      ii. Running 3-0 Vicryl, 4-0 Monocryl (caution lateral cutaneous nerve)
      iii. May use Dermabond or steri strips
   b) Drain (i.e Blake drain 10 F) to site if appropriate (Low threshold to drain to avoid potential compartment syndrome as it would be very hard to ascertain in the initial post-op phase with a wrapped-up forearm in an intubated patient)
   c) ACE wrap

Postoperative Phase

1. **Pharmacologic: Antispam Protocols**
   a) Intravenous Nitrates:
      i. Nitroglycerin 5mcg/min for 24 hours postop then transition to oral nitrate or calcium antagonist for up to one year (16, 17). (A 3-month duration may be more practical as most calcium channel blockers and

nitrates are eventually stopped by that time by Cardiology/PCP as they often miss the indication for their usage)

ii. If a patient is on Milrinone, there is no need for nitrates

b) Oral Vasodilators: (choose one)

i. Isosorbide dinitrate 10mg TID -or- 30mg long-acting QD. Continue for 3 months.

ii. Amlodipine (Norvasc) 5mg po daily. If the patient has hypotensive tendencies, this can be decreased to 2.5mg daily. Amlodipine is generally preferred to diltiazem as it has less synergy with beta blockers for bradycardia, which is an important consideration along with fewer other drug interactions.
Diltiazem (Cardizem) 30 mg, QID starting POD 1. Change to 120mg long-acting QD on discharge. Continue for 1-3 months.

2. Monitoring

a) Pulse oximetry on the harvest extremity

b) Elevate arm on 1 -2 pillows to reduce arm edema

c) Assess capillary refill, digit color and temperature, and sensory and motor function routinely (Numbness and tingling of the thenar eminence is sometimes present and typically will subside with time).

d) No IV's, blood draws, or blood pressure in harvest extremity for four weeks from the date of surgery. Place LIMB ALERT in the electronic medical record. Keep sign in room and place LIMB ALERT bracelet on the arm

3. Wound Care

a) Remove drain POD # 1-2 or when output <50ml/24hr

i. The character of the effluent should also be considered.

b) Remove ACE wrap POD 1 or after drain removal

c) Steri-strips (no need if using skin glue in the OR)

APPENDIX A

Modified Allen's Test

A preoperative modified Allen's test is conducted in the following manner. In this test, the patient makes a clenched fist, and the radial and ulnar arteries are compressed firmly at the wrist by the examiner. While compression is maintained, the patient slowly opens the wrist and incompletely extends the fingers (hyperextension can produce a false positive result). When the ulnar artery is released, a hyperemic response extending to the thenar eminence and thumb within 5 seconds indicates adequate collateral circulation by the ulnar artery and non-dominance of the RA. Caution: If the radial artery is not completely occluded during the test, this can lead to false negative test (i.e., the examiner falsely observes adequate ulnar artery collateral flow). Conversely, false-positive tests may occur (i.e., the examiner falsely observes in-adequate ulnar artery collateral flow) if the wrist is hyperextended (Habib J, Baetz L, Satiani B. Assessment of collateral circulation to the hand prior to radial artery harvest. Vasc Med. 2012 Oct;17(5):352-61. doi: 10.1177/1358863X12451514. Epub 2012 Jul 19. PMID: 22814998.)

APPENDIX B

Options for Proximal Anastomosis Sites

If an arterial aortocoronary graft (RA or free IMA) is required, but size of arterial graft is small and/or considered too fragile for direct aortic anastomosis, the proximal anastomosis of the arterial graft can be constructed using a composite technique. A short segment of SVG is anastomosed to the ascending aorta in the usual fashion, using a 6.0 polypropylene suture. Thereafter, the arterial graft is anastomosed to the hood of the SVG, using a 7.0 or 8.0 polypropylene suture. In this case the SVG orifice should not be created with a punch, but rather by incising the SVG with a scalpel. After the arterial graft-SVG anastomosis is completed, a clip is placed in the end of SVG, distal to the anastomosis (24).

Off the Hood of another constructed SVG graft: A venotomy is performed of about 3-5 mm (usually on the largest vein graft), followed by sewing of the radial end to side with 7-0. If the vein is thick, a careful excision of a small portion of the vein hood will be performed for a better oval opening similar to what is sometimes done on reoperations sewing a proximal to vein "bubble".

An alternative is to make a vein Chimney graft with a section of the vein (in other words do a proximal vein anastomosis to aorta) and divide about 3mm distal to that anastomosis. Then sew the RA to the vein chimney in an end–to–end fashion with 7-0 Prolene suture. This is an easier approach to use than making a vein patch and is unlikely to get significant vein graft disease in the first 3 mm of vein to aortic anastomosis.

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ACKNOWLEDGEMENTS

We would like to recognize and thank the Radial Artery Use Best Practices Committee volunteers for their participation and thoughtful contributions:

Fouad Azoury, MD	McLaren Regional Hospital
Sanjay Batra, MD	Ascension St. John
Reza Dabir, MD	Ascension St. John
Alphonse DeLucia, MD	Bronson Methodist Hospital
Karsten Fliegner, MD	St. Joseph Mercy Oakland Hospital
Divyakant Gandhi, MD	McLaren Greater Lansing
Baron Hamman, MD	Beaumont Hospital Dearborn
Bakri Kaakeh, MD	Covenant Health
James Martin, MD	McLaren Port Huron
Francis Pagani, MD, PhD	University of Michigan
Andrew Pruitt, MD	St. Joseph Mercy Hospital Ann Arbor
Timothy Sell, MD	Beaumont Hospital Dearborn
Marc Silver, MD	St. Joseph Mercy Oakland Hospital
Hisham Qandeel, MD	Sparrow Hospital