Radial artery for coronary artery bypass grafting: does proximal anastomosis to the aorta or left internal mammary artery achieve better patency?

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Received 21 March 2013; received in revised form 28 June 2013; accepted 8 July 2013

Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was ‘in coronary artery bypass grafting using radial artery grafts, does proximal anastomosis to the aorta or left internal mammary artery achieve better patency’. Altogether >183 papers were found using the reported search, of which 9 represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. Radial artery grafts typically have a narrower lumen than vein grafts, and as such there is some concern that anastomosing them directly to the aorta during coronary artery bypass grafting (CABG) may impair graft patency. As such, some surgeons prefer to anastomose radial artery grafts to a second-order vessel such as the left internal mammary artery (LIMA). We sought to assess the evidence for this. A handful of papers directly addressing the issue of the effect of the site of proximal anastomosis on graft patency were found, with three showing no significant difference. One such study reported an insignificant difference in angiographic patency at 32 months postoperatively, with 94.1% of off-aorta grafts remaining patent vs 87.2% of off-LIMA grafts (p = 0.123). However, a large-scale well-designed study was able to demonstrate a statistically significant difference at five years postoperatively, with 74.3% of off-aorta grafts patent, compared with 65.2% of off-LIMA (p = 0.004). Nonetheless, a number of papers that report patency for either off-aorta or off-LIMA grafts give comparable figures for each technique. Additionally, different centres and investigators report very different patency results for grafts that have the same site of proximal anastomosis. One centre was able to achieve patency rates for off-LIMA grafts of 88% up to a mean of 7.7 years postoperatively while another centre reported a patency rate of only 78.6% at three years. Given this, and the plethora of other factors influencing graft patency, we conclude that the best evidence suggests that the site of proximal anastomosis has little or no effect on radial artery graft patency following CABG.

Keywords: Review • Artery • Patency • Coronary artery bypass graft

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1].

THREE-PART QUESTION

In [patients undergoing a coronary artery bypass graft] does [proximal anastomosis to the aorta or the left internal mammary artery] achieve [better patency]?

CLINICAL SCENARIO

While observing a coronary artery bypass graft (CABG) procedure in theatre you notice that the consultant uses the left internal mammary artery (LIMA) as the site of the proximal anastomosis for the radial artery (RA) graft being used. You ask why she does not make the anastomosis directly onto the aorta—as is commonplace with vein grafts. She explains that this is because attaching the RA, which has a relatively small lumen, directly onto the aorta is thought to impair the patency of the graft. You resolve to check the literature on this topic.

SEARCH STRATEGY

<table>
<thead>
<tr>
<th>Author, date, journal and country</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Jung et al. (2009), J Thorac Cardiovasc Surg, Republic of Korea [2]</td>
<td>1735 patients, of which 893 received serial CT coronary angiographies, 451 with an aortic anastomosis, 442 with LIMA. All follow-up was with CT angiography and was performed as per protocol, rather than symptom-led</td>
<td>Early patency</td>
<td>CT angiography 6 months after CABG showed patency in 98.3% for off-aorta RA grafts compared with 94.5% for off-LIMA</td>
<td>This study compared the patency of RA grafts when either anastomosed to the aorta or LIMA. A large number of patients were included. Although a single radiologist reviewed the CT angiograms, there was no selection bias between the two groups and undergoing a follow-up CT angiogram, therefore a valid intergroup comparison can be made. Theses angiograms were evaluated using visual assessment rather than quantitative angiography. The results demonstrate superior early and late patency in off-aorta RA grafts in comparison with those off-LIMA</td>
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<td>Yie et al. (2008), Eur J Cardiothorac Surg, Republic of Korea [3]</td>
<td>A single centre carried out CABG on 488 patients. From these, 123 patients were studied with postoperative direct angiography at a mean of 32 months. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Patency of RA (depending on site of proximal anastomosis)</td>
<td>The overall patencies of off-aorta RA grafts was 112/119 (94.1%) compared with off-LIMA 48/55 87.2% LIMA, (P = 0.123)</td>
<td>In attempting to evaluate the mid-term RA graft patencies, in off-aorta and off-LIMA anastomoses, using visual and quantitative assessment of angiograms, the authors demonstrated that the location of proximal anastomosis failed to have an effect. This could be due to the small study population used. The angiograms were review by two cardiac radiologists</td>
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<td>Maniar et al. (2003), Ann Thorac Surg, USA [4]</td>
<td>A total of 1505 patients underwent CABG of which 483 received an off-aorta RA graft and 1022 an off-LIMA RA graft. Those who had symptoms of myocardial ischaemia underwent postoperative cardiac catheterization and were assessed with direct angiography in a symptom-led manner</td>
<td>Incidence of postoperative angiography</td>
<td>RA patency increased steadily with increasing target stenosis</td>
<td>In order to assess the optimum use of RA grafts, the patency in off-aorta and off-LIMA were investigated. However, the results showed that the location of the proximal anastomosis had no significant influence on patency. Only a small subset had an angiogram and it would have been of interest to ascertain if others had symptoms but no angiography. Due to the lack of serial control angiography, an assumption that graft failure was the same date as cardiac catheterization is imposed. A large number of surgeons carried out the procedures, which would result in variations in surgical technique</td>
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**Table 1**: Best evidence papers
Table 1:  (Continued)

<table>
<thead>
<tr>
<th>Author, date, journal and country</th>
<th>Study type (level of evidence)</th>
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<th>Outcomes</th>
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<tr>
<td>Al-Ruzzeh et al. (2005), J Card Surg, UK [5]</td>
<td>Uncontrolled retrospective cohort study with a prospective element (level III)</td>
<td>The notes of 600 patients who underwent CABG with an isolated RA graft were retrospectively analysed to evaluate their postoperative course. Of these, 93 patients consented to direct angiographic follow-up on the fourth postoperative day and this was prospectively analysed. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Mortality from the procedure</td>
<td>There were 4 in-hospital deaths representing 0.6% of the cohort</td>
<td>The primary aim of this paper was to retrospectively analyse clinical course following CABG with RA grafts in older patients in order to validate its use. Angiographic analysis of RA patenty is a secondaty outcome. The results would suggest that off-aorta grafts have better patency but only a small total number of grafts were stenosed, making interpretation of the results difficult. Additionally, all angiograms were analysed by one, unblinded, investigator in a relatively subjective manner. However, this paper does directly compare off-aorta to off-LIMA RA grafts</td>
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<td>Deb et al. (2012), J Am Coll Cardiol, Canada [6]</td>
<td>Randomized controlled trial (level II)</td>
<td>510 patients aged &lt;80 years receiving primary isolated non-emergent CABG from 9 centres were investigated. Of the eligible 358 patients, 234 underwent direct angiography at a mean of 7.7 ± 1.5 years postoperatively with 35 being followed up with CT angiography. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Functional RA graft occlusion</td>
<td>There was an occurrence of 28 RA grafts with functional occlusion (12.0%)</td>
<td>The author’s purpose was to present off-LIMA RA graft failure rates over 5 years after CABG and hence no comparison with off-aorta grafts is made. Functional graft occlusion using invasive angiography was used in assessment, performed by 5 cardiologists in a blinded fashion. All patients received a vein study graft in addition to the RA graft and therefore this reduces the generalizability of the results. Furthermore nearly a quarter of those eligible were not followed up and patients recruited to the study were generally low-risk</td>
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<td>Cho et al. (2011), J Card Surg, Republic of Korea [7]</td>
<td>Retrospective cohort study (level III)</td>
<td>RA composite grafting with the LIMA was performed in 352 patients with outcomes compared with 45 patients who received a right internal thoracic artery graft. Of the RA cohort, 306 patients received follow-up with CT angiography. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Patency of RA grafts</td>
<td>1 and 3 year patency rates for RA grafts were 84.8 ± 2.3% and 78.6 ± 3.4%, respectively</td>
<td>The authors compared outcomes in patients receiving an RA graft to those with a RITA graft. They obtained RA graft failure rates at 1 and 3 years as well as major adverse event rates. There was a high CT angiographic follow-up rate, with the resulting CT angiograms reviewed by a number of radiologists</td>
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<td>Hayward and Buxton (2011), Heart Lung Circ, Australia [8]</td>
<td>Randomized controlled trial (level II)</td>
<td>Recruitment of a total of 311 patients was randomized to a RA graft arm, of which 173 had direct angiographic follow-up at a mean interval of 5.5 years post-surgery. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Mortality</td>
<td>Mortality was compared between patients receiving an RA graft and those receiving RITA or SVG grafts. No significant mortality difference was seen</td>
<td>This paper is a mid-term report of results of the RAPCO trial, with full results available in 2014. Therefore, it is not possible to draw definitive conclusions until all patients have been followed up. However, the mid-term results provide a quantitative measure of RA patency for off-aorta grafts</td>
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<td>Collins et al. (2008), Circulation, UK [9]</td>
<td>82 patients aged 40–70 years, undergoing elective primary isolated CABG in a single centre, were randomized to receive a RA graft. 59 of which were followed up with direct angiography. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Patency of RA graft</td>
<td>5 years after surgery, only 1 RA graft had stenosed (1.7%), and there was graft narrowing seen in 6 (10%)</td>
<td>The main aim of the study was to look at mid-term and long-term in off-aorta RA grafts. The primary endpoint used was angiographic graft patency at 5 years postoperatively. Three independent observers were used to review the angiograms, which were assessed with a detailed grading system. However, the patient group used was small and low-risk. Furthermore, few women were investigated and as such results can only be applied for men</td>
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<td>Possati et al. (2003), Circulation, Italy [10]</td>
<td>90 consecutive, surviving patients in which RA was proximally anastomosed with the aorta were followed up. The majority of subjects were men in their 60 decade. The long-term follow-up was carried out at a mean 105 ± 9 months with direct angiography. Angiography was performed as per protocol, rather than symptom-led</td>
<td>Patency of RA graft</td>
<td>Of 84 RA grafts investigated at long-term follow-up, 10 did not maintain perfect patency (11.9%), and 7 were occluded (8.3%). Of those that were patent at 5 years, 100% remained open at the long-term follow-up</td>
<td>The study describes long-term off-aorta RA graft patency rates. The same surgical team performed the procedures for each patient. The data for patency failure indicates that this occurs in the first years post-surgery</td>
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CT: computed tomography; LIMA: left internal mammary artery; CABG: coronary artery bypass grafting; RA: radial artery; RITA: right internal thoracic artery; RAPCO: radial artery patency and clinical outcomes; SVG: saphenous vein graft.

SEARCH OUTCOME

One hundred and eighty-three papers were found using the reported search. From these, nine papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

RESULTS

Only four papers directly compare the patency of off-aorta and off-LIMA RA grafts. However, a number of studies report patency rates using one of the two techniques, enabling between-study comparisons to be drawn.

Jung et al.’s paper [2] allows for a direct comparison between RA grafts with aorta or LIMA proximal anastomoses in a large cohort of patients. Of the 451 off-aorta grafts, 98.3% were assessed as patent on computed tomography (CT) angiography 6 months postoperatively, compared with 94.5% of the 442 off-LIMA grafts (p = 0.004). Five-years post-surgery, off-aorta RA grafts were patent in 74.3 ± 6.1% of cases, compared with 65.2 ± 4.2% of off-LIMA grafts (p = 0.004). While this study was non-randomized, this paper directly compares angiographic patency following grafting via both techniques. It provides strong evidence to suggest that off-aorta grafts have improved patency in both the short and long term.

Yie et al., in 2008, [3] also directly compared the effect of the site of the proximal anastomosis on angiographic patency at a mean of 32 months postoperatively. They found that 112/119 (94.1%) of off-aorta grafts remained patent, compared with 48/55 (87.2%) of off-LIMA grafts. However, this difference did not reach statistical significance (P = 0.123), suggesting that the site of proximal anastomosis has no effect.

Maniar et al. [4] corroborated these findings as they were also unable to demonstrate a significant difference between the two groups. In this interesting study, the authors performed angiograms on 203 patients at an average of 26.1 ± 18.5 months following CABG with RA grafts anastomosed to either the aorta or to the pedicled LIMA as a composite T graft. They reported patency in the off-LIMA group at 70% vs patency in the off-aorta group of 75% (P = 0.42). However, the authors of this study only performed angiography on those patients who displayed symptoms and signs of myocardial ischaemia—postoperative angiography was not routinely performed. It is, therefore, difficult to draw conclusions regarding the true patency of the grafts in each group and this is a major flaw of the study.

Al-Ruzzeh et al., in 2005, [5] also compared patency rates of RA grafts anastomosed to the aorta with those anastomosed to the LIMA. They found that 5/70 (7.1%) of off-aorta grafts and 2/11
(18%) of off-LIMA grafts were stenosed on angiography performed before discharge following CABG. The author's primary aim was to retrospectively analyse the clinical course following CABG with RA grafts in older patients in order to validate its use. No statistical analysis was provided for the comparison of patency depending on the site of proximal anastomosis. However, based on the low numbers of patients involved, it is unlikely that a statistically significant difference would have been seen. Furthermore, these data were obtained early in the postoperative course and no longer-term angiographic follow-up was obtained.

Deb et al., in 2012, [6] evaluated 5-year patency of RA grafts anastomosed to the LIMA as part of the radial artery patency study (RAPS)—which compared RA grafts to saphenous vein grafts in coronary bypass operations. They found that at a mean of 7.7 ± 1.5 years postoperatively, 12% of RA grafts were functionally occluded on invasive angiography. This well-designed study with blinded observers allows for long-term patency rates to be established, but unfortunately does not look at the patency of off-aorta grafts, preventing a within-study comparison of these approaches.

Cho et al., in 2011, [7] reported patency rates at 1 and 3 years following RA grafting onto the LIMA in a large cohort of patients. They found that at 1 year, 91.8 ± 4.3% of grafts appeared patent on CT angiography, while at 3 years the 78.6 ± 3.4% of grafts were patent. This reflects a less successful off-LIMA patency rate for RA grafts than Deb et al.’s study.

Hayward and Buxton [8] reported mid-term angiographic data from the radial artery patency and clinical outcomes (RAPCO) study, showing that 17/173 (9.8%) of RA grafts failed (including stenosis, occlusion and string sign) at a mean of 5.5 years postoperatively. While full-term results for this study are expected in 2014, all grafts in this study were proximally anastomosed to the aorta (described in a earlier publication) and hence the mid-term data are able to provide patency rates for this technique.

In Collins et al.’s 2008 [9] UK-based study, the authors compared the angiographic patency of off-aorta RA grafts at 5 years with those of SVG grafts, hence reporting 5-year data for this type of an RA grafting technique. They state that 89% of grafts had ‘perfect patency’, while the other 11% had some degree of graft narrowing and 2% of grafts were totally occluded. Importantly, this paper used invasive angiography in all patients after a defined follow-up period—like other studies utilizing variable follow-up periods and angiographic methods. However, in this single-centre trial, there was no mention of a review of the angiograms by multiple specialists or whether the degree of narrowing was objectively measured.

Possati et al.’s [10] elegant study used the same surgical team for every patient and provided long-term off-aorta RA graft patency rates. Of note, 10/84 (11.9%) grafts failed to maintain perfect patency while 7 (8.3%) were occluded at 105 ± 9 months. Interestingly, the authors found that of the grafts that were patent at 5 years, 100% remained patent for the long-term follow-up, indicating that stenosis is most likely to occur in the first 5 years.

CLINICAL BOTTOM LINE

Postoperative patency of grafts following CABG has important clinical and prognostic implications. A handful of papers directly address the issue of the effect of the site of proximal anastomosis on graft patency, with three showing no significant difference. However, a large-scale well-designed study showed that off-aorta grafts had significantly improved patency at 6 months and 5 years postoperatively. Nonetheless, a number of studies that report patency for either off-aorta or off-LIMA grafts give comparable figures for each technique. Additionally, different centres and investigators report very different patency results for grafts that have the same site of proximal anastomosis. Given this, and the plethora of other factors that influence graft patency, the best evidence suggests that the site of proximal anastomosis has little or no effect on RA graft patency following CABG.

Conflict of interest: none declared.

REFERENCES