How do Surgeons Decide? Conduit Choice in Coronary Artery Bypass Graft Surgery in the United Kingdom

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Introduction

Choice of conduit for Coronary Artery Bypass Grafting (CABG) is often a point of contention amongst cardiac surgeons. Conduit choice is particularly important as it has a significant impact on graft patency and consequently on long term outcomes. Whilst a left internal mammary artery (LIMA) graft to the left anterior descending artery has been proven to provide a significant survival benefit and is the gold standard conduit[1], the quest for the second best conduit in multiple revascularisation remains unsolved and evidence is inconclusive[2].

Although studies have shown a substantial failure rate of saphenous vein grafts (SVG) after 1 year (10-20%) and thereafter (5% for each additional year), most recommendations favouring arterial revascularization are Class IIA, Level B evidence, which suggests that it is reasonable to perform the procedure, however limited populations have been evaluated and additional studies with focused objectives are needed[3]. Recently, Total Arterial Revascularisation (TAR) and use of Bilateral Internal Mammary Arteries (BIMA) have become increasingly popular in many countries. Use of TAR is estimated to be about 20% in Europe and up to 80% in Australia but remains low in America with approximately 5% of patients undergoing CABG receiving TAR[4–6]. However, the evidence is mixed and there is large variation in current practice, reflecting the scarcity of sufficiently powered, prospective, randomized studies with long-term follow up. Patients are now increasingly complex and there is no formal classification for patients who may benefit most from arterial grafts, though some surgeons tend to favour arterial grafts in younger patients.

There has been significant research interest in long term patency and several studies pertaining to use of the right internal mammary artery (RIMA) and radial arteries. However, surgeons may be reluctant to use these conduits given the lack of concrete evidence and clear guidelines. Current long-term evidence pertaining to BIMA and TAR have been in the form of observational studies, and no randomised trials have been completed to date. Taggart and colleagues have recently completed the 10-year follow up of the arterial revascularisation trial, a randomised controlled trial comparing single vs bilateral internal mammary artery grafting, of which the results are awaited. Recent guidelines from the Society of Thoracic Surgeons and the European Society of Cardiology/European Association for Cardiothoracic Surgery promote the use of arterial grafting, particularly in young patients, but concede that decision-making may be complex, particularly in patients at increased risk of sternal complications[3,7]. Some studies suggest the risk may be reduced by using skeletonized grafts but once again studies producing higher levels of evidence are needed to delineate the best approach and patient selection to reduce sternal wound complications.

In addition to the international variation in conduit use demonstrated by previous studies, there is also likely to be regional variation and differences on a hospital level between consultants. Such discrepancies in practice may inadvertently affect patient outcomes and not appropriately account for inter-patient differences when deciding the most appropriate approach or intervention. For instance, arterial grafting may be under-used in younger patients at some centres while it may be over-used in frail patients or emergency cases. No study to date has reported on the individual variation in practice within a region and ultimately surgeons' opinions are grossly varied. While RCTs are needed to provide reliable evidence for clinical effectiveness and an audited registry could determine true usage of conduits, a survey is required to identify and understand surgeons' personal convictions about what conduits they should use and why they use it. This study investigates the conduit choices and current practices of UK consultant cardiac surgeons as well as the decision making processes behind them.

Methods

Questionnaire Development

A questionnaire consisting of 10 questions was devised and trialled on five cardiothoracic surgical registrars to assess clarity and ease of understanding (Table 1). Four questions were created using the Ottawa Decision Support Framework (ODSF) to elicit the importance surgeons placed on various factors in conduit choice and grafting methods on a Likert scale from 1 – 10 (1: least important; 10: most important)[8]. Regular as well as occasional conduit choices, changes to routine practice in frail patients or emergency cases, and preferred vein harvesting methods were also elicited. Additionally, decision making on conduit choice was assessed by asking surgeons to allocate a total of 10 points between various factors based on importance. Free space text boxes were also provided for surgeons to give reasoning behind their choices or any further comments.

Data Collection & Eligibility

Between February and October 2017, questionnaires were disseminated by medical student members of the UK Undergraduate Cardiovascular Research Network in collaboration with the Cardiothoracic Trainees Research Collaborative. Each medical student was designated as the local study lead for one UK cardiothoracic centre and responsible for collecting data in person from all cardiac surgeons at the assigned centre. All UK consultant cardiac surgeons currently performing coronary artery bypass grafting were eligible for inclusion. All study participants received a participant information sheet. All questionnaires were scanned in original form and sent by email to the study co-ordinators (S.J. and M.G.) and collated centrally for further analysis. All participant names and institutions were anonymised.

Data Analysis

All data was analysed centrally using quantitative and qualitative analyses. For questions utilising the ODSF (questions 3 - 6), scores of 8, 9, 10 were classified as ‘important’ and 1, 2, 3 as ‘not important’.

Thematic analysis was performed on all free-text answers and comments provided in designated boxes. For the four comment boxes accompanying the ODSF questions, comments were first stratified into three groups based on the score given to the subject in question. Scores of 8, 9 or 10 were ‘for’ the subject in question and scores of 1, 2 or 3 were ‘against’, whilst scores of 4, 5, 6, or 7 were deemed to be in the ‘middle’. Recurring themes in each of the three groups were identified for each question and each comment was then screened and classified into one or more themes. Themes were analysed both as a total cohort and within each of the three subgroups.

Two questions on changes to practice in the context of different patient scenarios (7 and 8) were free-text and responses were first classified into those who would not change their

practice and those who would. Amongst those who would change their practice, responses were further analysed and divided into the types of changes that would be made.
All scores are presented as means ± standard error of the mean. SPSS Statistics v24.00 (SPSS Inc, IBM, Chicago) was used for all statistical analysis.

Table 1: Questionnaire - "Coronary Artery Bypass Graft Conduits: Current Opinion Amongst UK Surgeons"		
1	Which of the following do you regularly use (i.e. several times a month)? Please tick all appropriate boxes (listed in alphabetical order).	☐ Gastroepiploic Artery ☐ Great Saphenous Vein ☐ Left Internal Mammary Artery (LIMA) ☐ Radial Artery ☐ Right Internal Mammary Artery (RIMA) ☐ Short Saphenous Vein
2	Which of the following would you feel comfortable using if only a few times a year? Please tick all appropriate boxes (listed in alphabetical order).	☐ Gastroepiploic Artery ☐ Great Saphenous Vein ☐ Left Internal Mammary Artery (LIMA) ☐ Radial Artery ☐ Right Internal Mammary Artery (RIMA) ☐ Short Saphenous Vein
3†	In a typical low risk patient in whom you plan 3 – 4 distal anastomoses and who has good left ventricular function, how important is it to you to use bilateral mammary arteries for grafting? 1 = least important; 10 = most important 1 2 3 4 5 6 7 8 9 10	
4†	In a typical patient as described above, how important is it to you to skeletonise your mammary vessels? 1 = least important; 10 = most important 1 2 3 4 5 6 7 8 9 10	
5†	In a typical patient as described above, how important is it to you for each graft to serve only one distal anastomosis rather than sequential, T or Y configurations? 1 = least important; 10 = most important 1 2 3 4 5 6 7 8 9 10	
6†	In a typical low risk patient in whom you plan 3 – 4 distal anastomoses and who has good left ventricular function, how important is it to you to use all arterial grafts? 1 = least important; 10 = most important 1 2 3 4 5 6 7 8 9 10	
7	In a frail patient with comorbidities, would your practice (as stated in Q3 – Q6) change? If yes, how?	
8	A patient undergoing PCI in the cath lab is brought for emergency surgery. Would your practice (as stated in Q3 – Q6) change? If yes, how?	
9	Please allocate to each of the following considerations a number of points based on its importance in affecting your choice of conduit. You have a **total of 10 points** available and can choose to distribute it amongst the factors below (listed in alphabetical order). 0 points = no effect on decision; 10 points = only factor mentioned affecting decision **Please ensure the total number of allocated points adds up to, but does not exceed 10**.	……. High quality evidence in the literature ……. Patient choice ……. The competency of the surgeon/practitioner harvesting the chosen conduit ……. Theatre time available ……. To provide a training opportunity ……. Your experience in the approach
10	In a typical patient as described above, please rank your preference for method of harvesting the great saphenous vein in order of preference (1 = most preferred, 3 = least preferred, X = never used)	……. Bridging Vein Harvest ……. Endoscopic Vein Harvest ……. Open Harvest
11	Do you have any other comments?	

*The consultant's name and affiliated hospital/institution were also recorded (and later anonymised)

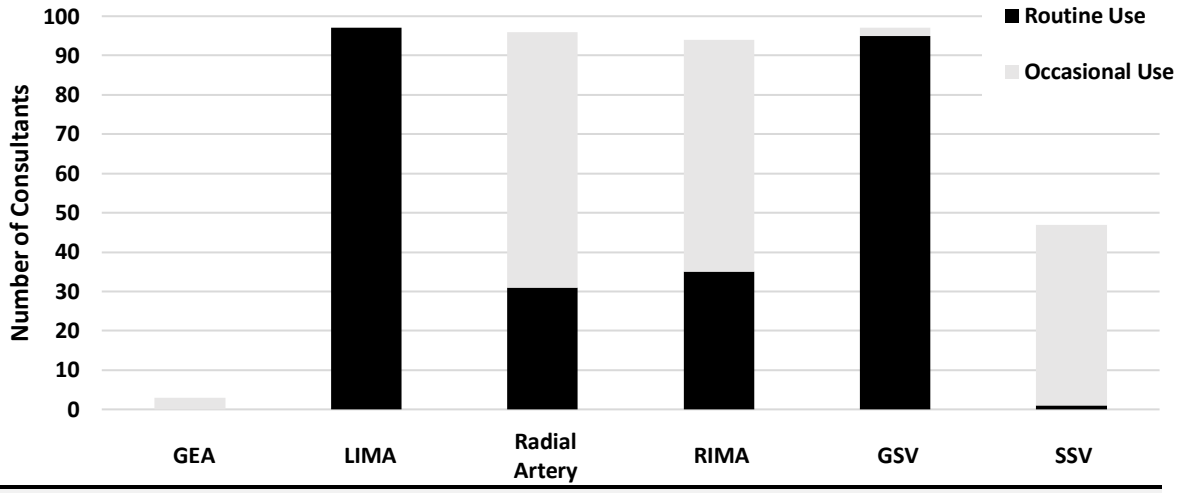
†Free text boxes also provided for further comments

Results

97 consultant cardiac surgeons from 25 UK cardiothoracic centre participated in this study, comprising of 42% of total cardiac surgeons and 78% of total cardiac surgical centres[9].

Conduit Choices

Cardiac surgeons answered questions on routine use of conduits, defined as used several times a month, or occasional, defined as may be used, if needed, a few times a year (Figure 1). As expected all 97 surgeons routinely used the LIMA and almost all used GSV routinely (n=95; 98%). The other 2 surgeons did not routinely use any veins as conduits, but used them a few times a year at most, if needed. Only 31 (32%) surgeons routinely used radial arteries and 35 (36%) used the RIMA as a conduit. However, most surgeons said they may occasionally use them if needed (RIMA: n=94, 97%; radial: n=96, 99%).



	GEA	LIMA	Radial Artery	RIMA	GSV	SSV
Routine Use*	0 (0%)	97 (100%)	31 (32%)	35 (36%)	95 (98%)	1 (1%)
Occasional Use†	3 (3%)	97 (100%)	96 (99%)	94 (97%)	97 (100%)	47 (49%)

Figure 1: 97 surgeons included in total
***Defined as several times a month**
†Defined as few times in a year
GEA: Gastroepiploic Artery; LIMA: Left Internal Mammary Artery; RIMA: Right Internal Mammary Artery; GSV: Great Saphenous Vein; SSV: Short Saphenous Vein

Vein Harvesting Methods

Participants were asked to rank their preferred method of harvesting the GSV from 1 (most preferred) to 3 (least preferred), and were also given the option of using an 'X' to indicate they never used that method (Table 2). Open harvesting was most frequently ranked as the preferred method, with 47 surgeons (48%) ranking it as their first choice, far ahead of endoscopic vein harvesting (EVH) or the bridging method, which were most preferred by only 32 (33%) and 22 surgeons (23%) respectively. It must be mentioned that 5 surgeons ranked two options equally as their first preference. However, open harvesting was also most frequently ranked as the least preferred method of vein harvest by 25 surgeons (26%), though it was closely followed by bridging and endoscopic harvests.

A large number of surgeons never use the endoscopic (n=24, 25%) or bridging (n=19, 20%) methods of vein harvesting in their practice. Notably, though there was no designated free text specifically for this question, 6 surgeons commented on their wish to use endoscopic vein harvesting more frequently but noted that lack of resources and appropriate training hindered its routine use.

Table 2: Preferred Methods of Vein Harvesting

	Bridging	Endoscopic	Open
1	22* (23%)	32* (33%)	47* (49%)
2	24 (25%)	16† (17%)	18† (19%)
3	24‡ (25%)	16‡ (17%)	25‡ (26%)
X	19 (20%)	24 (25%)	2 (2%)
Blank (no response)	9 (9%)	9 (9%)	5 (5%)

*1 response ranked bridging = e**ndoscopic for 1st** preference;
2 responses ranked open = e**ndoscopic for 1st** preference;
2 responses ranked open = b**ridging for** 1st preference
†1 response ranked Open = Endoscopic for 2nd preference
‡1 response ranked open = Endoscopic for 3rd preference; 1 response ranked Bridging = Endoscopic for 3rd preference; 2 responses ranked Open = Bridging for 3rd preference

Importance of Conduit-Related Factors

Participants had to score the importance of using BIMA, skeletonisation, single proximal-distal anastomosis and total arterial revascularisation in response to four "how important is it to you…" questions (Table 3, Figure 2).

94 consultants provided a score for the importance of using BIMA. BIMA usage showed a distinctive bimodal distribution with 29 (31%) 'important' (scoring 8, 9 or 10) and 'not important' (scoring 1, 2 or 3) scores each. On either extreme, 18 surgeons gave BIMA an importance of 10/10 whilst 13 gave it a 1/10. 12 surgeons gave it a 5/10. Out of 51 consultants who provided comments, 27 (53%) indicated that age was a factor in their decision, and more consultants were willing to use BIMA in younger patients. While most people did not state an age range, when stated, the age threshold varied between <45 years to <75 years. Out of those preferring not to use BIMA (n=29), 14 consultants provided comments out of which 6 (43%) stated there was no evidence behind BIMA, while another 6 said their decision would depend on the age of the patient. Other reasons for not using BIMA in this subgroup included presence of comorbidities (most commonly stated include diabetes or COPD), and increased difficulty of re-operation. Of those in the middle group (n=36), 21 participants commented with the majority stating that their decision depended

on the patient's age and they would be more willing to use BIMA in younger patients, whilst 2 stated they would take into account the target vessels and location and extent of stenosis. 6 stated they would avoid BIMA in comorbidities while 3 people in this group stated there was no evidence for BIMA despite giving it a "middle" importance rating. Out of the 16 patients who commented in the using BIMA group, 5 participants stated it would depend on age and 5 stated it would depend on their comorbidities. Only 2 explicitly stated their use of BIMA was backed up by evidence. Overall, 3 participants acknowledged it was useful for enabling minimal aortic manipulation and in certain unspecified comorbidities.

Most surgeons (n=62/95, 65%) preferred pedicled mammary arteries with 47 (49%) assigning skeletonisation a score of 1 out of 10 and the remaining 15 giving a score of 2 or 3. 20% of surgeons rated skeletonisation of mammary arteries as important to their practice. The main reasons surgeons gave against skeletonisation were no evidence of benefit (7 comments), while 3 comments also highlighted the added risk for damage or spasm and potentially poor long-term patency. There were also 9 subjective comments highlighting a general dislike for skeletonisation. The main reasons for skeletonisation were to increase length with 3 surgeons in the 'against skeletonisation' group suggesting they would consider skeletonisation if needed to increase length of the IMA. Other reasons for skeletonisation were to reduce sternal wound complication rates (4 comments in total) or to enable sequential grafting, with 4 out of 12 surgeons who commented in the 'for skeletonisation' group identifying this as their primary reason for skeletonisation.

Less than a quarter of surgeons (n=22; 23%) found TAR important. 37 surgeons said that TAR was not important to their practice, with the mode being a score of 1, which was given by 14 surgeons. The average score for TAR was 4.86 out of 10 and the median was 4 out of 10. Reluctance to adopt TAR seemed to stem from a lack of concrete data, with 6 consultants citing lack of evidence. 43 surgeons provided comments, out of which 16 said use of TAR would depend on patient age, though specific ages were not stated. 16 surgeons said it would depend on the anatomy and disease spread in target vessels, with several specifying a preference for using arterial revascularisation in the left coronary system.

The majority of surgeons (n= 56) highly valued a single proximal to distal anastomosis, with only 25 surgeons (26%) finding sequential, T or Y grafts important. While 10 comments acknowledged it was useful in instances where conduit length was limited, including 7 consultants in the 'for single proximal-distal anastomoses' subgroup, there was still an overwhelming preference for a single proximal-distal anastomosis. This was in part due to the risk of potential loss of multiple anastomosis with one graft failure (with 8 participants, all in the 'for single proximal-distal anastomosis' subgroup, indicating they felt uncomfortable with this risk). Four participants, across all subgroups, also acknowledged it was technically challenging and they had less experience in sequential or Y-grafts compared

to traditional anastomosis. Other advantages highlighted in the comments were to minimise aortic manipulation and enable the no-touch aortic technique.

Table 3: Importance of Conduit-Related Factors

	Importance of Using Bilateral Internal Mammary Arteries *(n = 94)*	Importance of Skeletonising the Mammary Arteries *(n = 95)*	Importance of a Single Proximal-Distal Anastomosis *(n = 95)*	Importance of Total Arterial Revascularisation *(n = 95)*
Average Score	5.6	3.5	6.7	4.9
# Scoring 1 - 3	29	62	25	37
# Scoring 4 - 7	36	14	14	36
# Scoring 8 - 10	29	19	56	22

Importance was ranked from 1 – 10, with 1 being the least important and 10 being most important.
Scores of 1 – 3 were classed as 'not important'
Scores of 8 – 10 were classed as 'important'

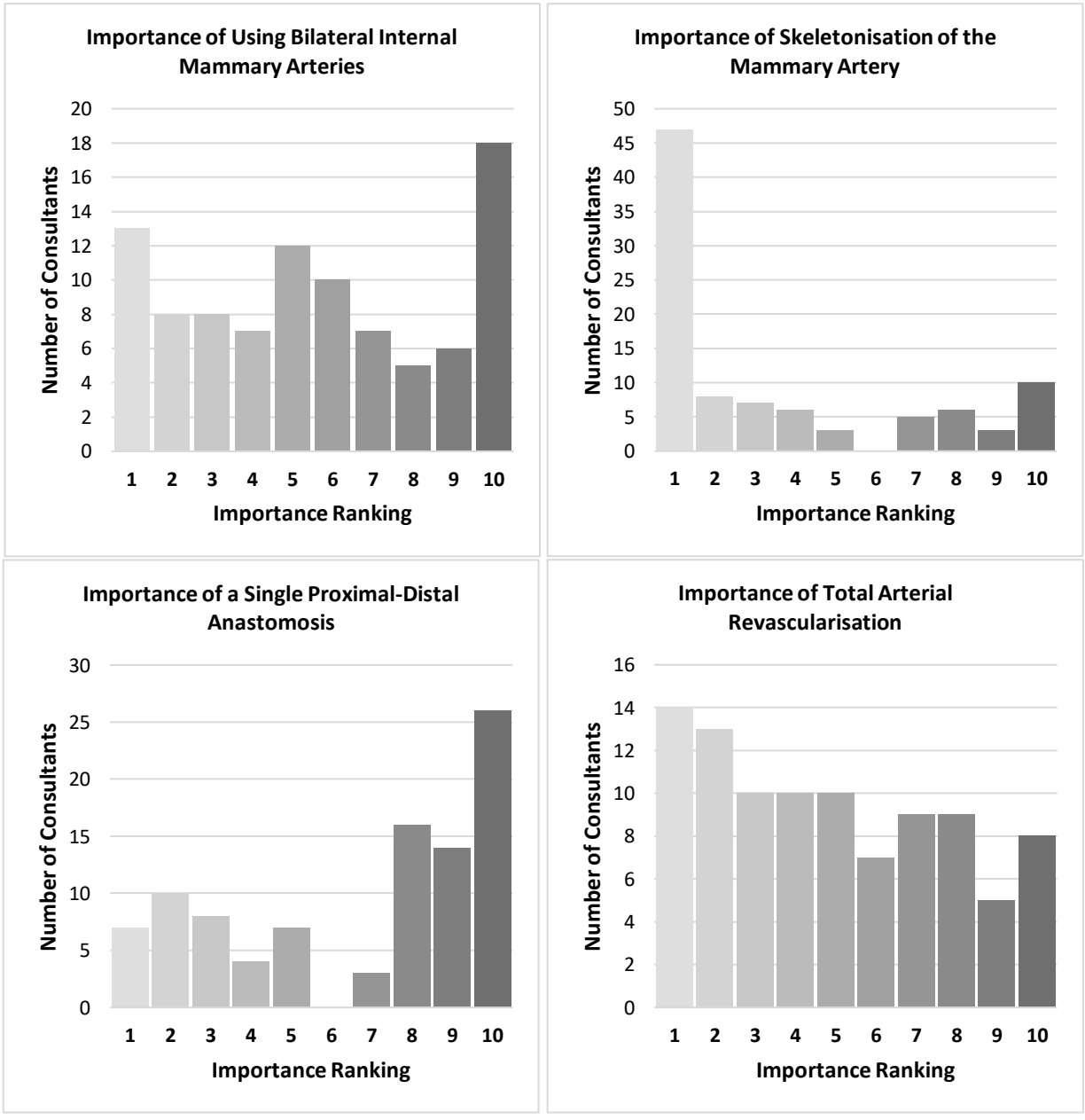


Figure 2: Importance of Conduit-Related Factors to UK Practice
1 = least important; 10 = most important

Changes to Practice for Different Patient Scenarios

Out of 97 consultant surgeons, 40 (41% of surgeons) said they would not alter their standard practice when presented with a frail patient with multiple comorbidities. Out of the remaining 57 surgeons, 32 (56%) surgeons said they would only use the LIMA and veins as a conduit, with 10 surgeons specifically stating they would not use BIMA in this cohort. 8 surgeons said they would use veins only, while 4 said they would attempt a shorter operation, which would be enabled by utilising only veins.

When faced with an emergency CABG, 17 out of 97 consultants said they would retain their standard practice. Amongst the 80 (83%) consultants who would alter their practice, 34 (43%) stated they would evaluate the haemodynamic stability of the patient and then opt for LIMA and veins in a stable patient or veins only if the patient is unstable. 4 consultants said they would still try to attempt BIMA, and 8 consultants said they would harvest LIMA on bypass, particularly if the patient is unstable. 10 consultants said they would choose LIMA and veins regardless, but avoid any other arterial grafts, whilst 13 said they would use only veins and 7 prioritised a shorter operation. Other common themes included the use of an intra-aortic balloon pump (4 consultants), and 5 consultants said the number of arterial grafts would depend on the age of the patient.

Surgeons' Decision-Making Processes on Conduit Choice

Each participant allocated a total of ten points amongst various factors which may affect the decision making process for choice of conduit (Figure 4/Table 4). Perceived evidence in the literature had the greatest impact on decision making, and was given a total of 328 out of 960 points* (34% of available points). The second most important factor was the experience of the consultant surgeon with the conduit (total 255/960 points, or 27% of available points). Competency of the harvester also played a part in decision making with 157.5 points (16% of available points). Theatre time and training had little impact on decision making with only 5% and 7% of available points, respectively. Patient choice was also given relatively limited importance (11% of available points).

**1 participant did not answer this question.*

Table 4: Factors Affecting Decision-Making on Conduit Choice

	High Quality Evidence	Patient Choice	Competency of Harvester	Theatre Time	Providing a Training Opportunity	Consultant Experience
Total Score (out of 960)	328 (34%)	107 (11%)	157.5 (16%)	48 (5%)	64.5 (7%)	255 (27%)
Average Score (out of 10)	3.38 ± 0.23	1.12 ± 0.13	1.66 ± 0.13	0.51 ± 0.081	0.69 ± 0.082	2.63 ± 0.18

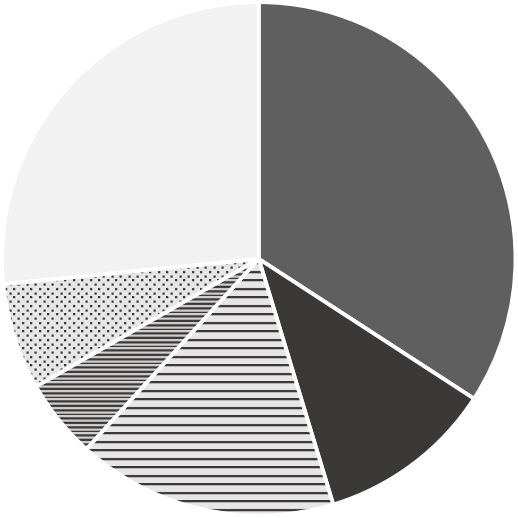


Figure 4: Factors Affecting Decision-Making on Conduit Choice

- Consultant Experience
- High Quality Evidence in the Literature
- Patient Choice
- Competency of Harvester
- Theatre Time
- Training Opportunity

Discussion

Total Arterial Revascularisation in the UK

In contrast to increasingly common practice in several other European countries and Australia[10], the majority of UK consultants in our study did not favour TAR. Relatively few surgeons use RIMA and radial artery conduits regularly and scores indicating low importance were given to bilateral mammary use and TAR. This is despite the STS Guidelines suggesting that as an adjunct to LIMA, a second arterial graft should be considered in appropriate patients.

However, the evidence for arterial revascularisation does indeed remain mixed. Opponents argue that there is no concrete evidence for multiple arterial revascularisation. This remains the main obstacle towards using TAR amongst UK consultants with 6 surgeons in our study commenting about the lack of evidence in favour of TAR. The largest randomised trial to date, the Arterial Revascularisation Trial (ART), has not demonstrated any benefit conferred by arterial revascularisation at five years of follow-up with no significant difference in outcomes between single internal mammary artery (SIMA) and BIMA use[11]. Moreover, BIMA use in ART was associated with higher sternal wound infection rates, including deep infections and some warranting sternal reconstructions[11]. Other studies have also demonstrated complications with wound healing related to use of BIMA, particularly in certain demographics, such as patients with chronic obstructive pulmonary disease, diabetes or a high body mass index[12,13]. This is reflected in the comments from our study which reveal uncertainty around which groups of patients will benefit most from BIMA, leaving some surgeons reluctant to utilise it as a conduit frequently. While surgeons were more willing to use BIMA and/or TAR in younger patients, there was a lack of consensus about the age cut-off with a suggested range of less than 45 years to less than 75 years, exhibiting considerable variation. Further studies on long-term outcomes with BIMA use in young patients as well as specific guidelines may increase its uptake for this cohort of patients.

On the other hand, the divergence in improved patency rates of the BIMA compared to LIMA and vein grafts may only appear past the 5-year mark as seen in previous studies. Preliminary results of ART unfortunately demonstrated little difference in a composite of death, MI or stroke between BIMA and LIMA alone[14], though the full paper is awaited. However, Tatoulis et al. demonstrated 5-year patency rates of 95% in a vein graft to the LAD compared to 98% in a LIMA to LAD graft. However, this dropped to 71% at 10 years and 32% at 15 years in a vein graft as opposed to 95% patency and 88% patency at 10 and 15 years respectively in the LIMA. In this context, the 5-year follow up of ART may underestimate the conferred benefit and the 10 year follow up results must be evaluated prior to concluding the insignificance of BIMA. Furthermore, several observational studies have described a

significant prognostic benefit from BIMA vs SIMA, but again, these have been demonstrated for a 10 year follow up period[15–17].

Given that the long-term patency of LIMA translates into improved 10 year survival and a reduction in major adverse cardiovascular events (MACE) in comparison to the relatively poor patency of the saphenous vein, the use of the RIMA may also confer a similar prognostic benefit to LIMA alone[1]. The LIMA derives its excellent results from the nature of its arterial wall, which has a thin muscular layer allowing for mechanical stretch, and displays a resistance to atherosclerosis[18]. The RIMA also has identical physiological properties. Furthermore, a study by Buxton et al. demonstrates identical long-term patency rates between the RIMA and LIMA over a 10-year period[19].

The risk of sternal infections with BIMA use may also be mitigated by using skeletonised conduits instead of pedicled conduits. Subgroup analyses of ART demonstrated a significant increase in sternal wound complication rates in the pedicled BIMA group (16.1%) compared to 9.5% in pedicled SIMA, but little difference between skeletonised BIMA (9.6%) and skeletonised SIMA (8%).[20] However, a strong preference for pedicled mammary arteries amongst UK are reflected in this study with 62 surgeons (64% of participants) rating skeletonisation as 'not important' to their practice, with 47 surgeons alone rating skeletonisation the lowest possible score (1 out of 10). This may also contribute to their reservations towards using BIMA as the need to skeletonise the arteries to minimise the risk sternal wound complication or perform sequential grafts may not appeal to some surgeons. Analysis of the comments further highlights a marked split between those that value skeletonisation and those that do not. Written opinions were strong, and a number of surgeons made direct statements against skeletonisation based on personal convictions as no clear clinical reasons were provided. Clinical reasons that were provided most commonly highlighted the risk of damage to the IMA with skeletonisation.

Interestingly, a large proportion of consultants in our study would not alter their practice for frail patients. This may reflect the 21st century cardiac surgery patient and the regularity of operating on older, multi-morbid patients. With advances in peri-operative care, more complex patients are now candidates for surgery.[21] Additionally, patients undergoing surgery for ischaemic heart disease are likely have a number of risk factors such as hypertension, diabetes, hypercholesterolaemia, vascular disease and other associated conditions.[22] Therefore, the average patient may in fact be frail with multiple comorbidities and therefore few changes may have to be made to the surgeon's routine practice. Emergency cases however drew a more uniform response, with the large majority of surgeons stating they would change their practice to either use no arterial grafts (all venous grafts), particularly if the patient is haemodynamically unstable, or just the LIMA, with a few surgeons harvesting the LIMA on cardiopulmonary bypass. This likely reflects the consensus on what constitutes an emergency, compared to the definition of a frail patient, as well as

the existence of more concrete guidelines for emergency CABG[7,23]. However, only one surgeon stated they would consider off-pump, which is also recommended in the guidelines.

It is also important to highlight that amongst those routinely using RIMA in this study, scores of 9 or 10 were most frequently awarded for its importance whilst surgeons not using the RIMA usually gave it scores of 1 or 2, indicating that there are strong opinions about its use as a second conduit on either end of the spectrum. This reflects the two schools of thought and contrasting interpretation of the literature existing amongst cardiac surgeons. This conflicting evidence may therefore explain the widespread distribution of importance scores and the two extremes of opinions held by cardiac surgeons with respect to total arterial revascularisation. Furthermore, this study also demonstrates the importance of evidence in the literature on decision-making, and the mixed evidence may therefore give rise to the two opposing types of practice.

The Second Best Conduit: Radial or RIMA?

The use of the radial artery as the second conduit has been met with particular scepticism due to its susceptibility to spasm and therefore potential to cause refractory angina[24]. Radial artery harvesting is also far more complex compared to a saphenous vein harvest, with greater potential for neurological injury, and surgeons and surgical care practitioners may often not be trained in the procedure[25]. It is also a more complicated operation in terms of the logistics and set up – while LIMA and veins can be harvested simultaneously and fairly quickly by an experienced harvester, harvesting the radial artery may add to theatre time and occasionally may not be done simultaneously with the LIMA, particularly if the harvest is occurring from the left arm.

Poor harvesting technique with excess handling also makes the conduit more prone to spasm[26]. Additionally the scar from a radial artery harvest is more visible and may be cosmetically less desirable for some patients. Despite these difficulties, Zacharias et al. have demonstrated a long-term survival benefit with a radial artery as the second conduit compared to a venous conduit[27]. However, the numerous disadvantages could explain the low use of the radial artery as a conduit amongst UK surgeons.

Ruttmann et al. have demonstrated a significant superiority of using BIMA compared to LIMA plus the radial artery as a second conduit, with significantly reduced cardiac and cerebrovascular events and improved overall survival in the BIMA group[28]. With these results and for reasons discussed above, the RIMA could feasibly serve as a reliable and beneficial 'second conduit' after the LIMA, though its current low uptake in the UK is likely explained by a lack of concrete evidence in the former of randomised controlled trials.

Decision Making Processes for Conduit Use

Though most surgeons felt they had adhered to evidence in the literature, there was a wide distribution in conduit choice and little consensus on topics such as TAR and use of BIMA. As briefly mentioned, the differences in conduit choices is likely due to varied evidence and ambiguous guidelines, and demonstrates the varied interpretation of published studies on this topic. However, it is also important to note that the questionnaire specified 'high-quality' evidence. Though it is arguable that the evidence isn't clear and participating surgeons have immensely divergent views, the majority of consultants feel that they are following high-quality evidence and feel existing literature is of a high enough quality to make their decisions. Yet, there is huge variation in decision making processes. The publication of the 10-year follow-up outcomes of the ART will provide more concrete evidence in the form of a multi-centre randomised controlled trial and allow for the development of clear cut guidelines.

Consultant experience was also an important factor suggesting that their training and exposure to conduits used in their institution could have a significant influence on decision making. This may also indicate that consultants do not feel comfortable experimenting with non-routine conduits and may be reluctant to learn new techniques. Opportunities to develop skills for those who are at consultant level are far fewer than those still in training, and when they do exist, are typically in advanced procedures such as robotic or minimally invasive surgery. Taking time off to become skilled in radial artery or RIMA harvesting is more difficult and consultants are therefore likely to have fewer opportunities to become comfortable with these conduits. BIMA is also much more time consuming and technically challenging compared to the conventional LIMA with GSV, though surgeons said theatre time available played little to no role in their decision making, and this is therefore unlikely to be the reason for the low uptake of BIMA.

While the need to provide training opportunities had little influence on conduit choice, consultants also indicated their experience with a particular approach played a big role in their decision-making. Presumably, their experience with conduits largely stemmed from their own training days, indicating that training has a significant impact on the conduits they go on to use in their future practice. Consequently, this may inhibit their own trainees from becoming proficient in harvesting conduits not used in their routine practice, or acquiring newer techniques, such as endoscopic radial artery harvesting, leading to a cycle whereby future consultant surgeons utilise the same conduits used by their trainers or mentors due to their limited experience with other conduits. Therefore, training programmes need to adopt a broader approach to ensure that trainees are getting exposure to the full set of techniques. This will ensure that if future evidence does show a concrete benefit of one of the less-used conduits, there will not be a sudden need to re-train an entire generation of consultants.

These factors need consideration when further evidence becomes available and guidelines are being written.

Endoscopic Vein Harvesting

Though open harvesting remains the most prevalent method in use, endoscopic vein harvesting (EVH) was surprisingly popular amongst cardiac surgeons in the UK. This is likely due to its numerous advantages over open vein harvest. These include decreased infection rates, reduced pain, which consequently leads to faster mobilisation, improved recovery and decreased length of stay, as well as better cosmesis[29,30]. However, there have also been concerns raised about the quality of the vein due to predisposition to clot formation during the EVH procedure[31]. Additionally, EVH is costly and requires additional training of the harvester. The bridging technique is also minimally invasive while technically easier than EVH, but it can cause a lot of trauma to the vein, which may explain its low uptake amongst surgeons in our study.

Conclusion

Understanding the decision making behind conduit choices may highlight potential barriers to change, and perception of evidence in the literature may facilitate further development of clinical guidelines and standardisation of practice. Different conduits might be best for different patients, however these subgroups of patients need to be identified and characterised through controlled trials rather than personal preferences based on low-quality evidence. Production and distribution of high-level evidence might persuade surgeons to follow guidelines rather than having to rely on personal convictions and judgements as most identified evidence-based practice as the principal driver of their decision-making. Additionally, sufficient surgeon training has to be organised by professional societies to improve the use of technically more challenging conduits, as removing the knowledge barrier to the use of TAR could both lead to improved results and confer benefits to particular subgroups of patients as outlined above.

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