Experience, Exposure and Attitudes Regarding Off Pump CABG Techniques in US Cardiothoracic Surgical Residents: Results of a Survey

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Central Message

Over half of graduating CTSR do not feel comfortable with OPCAB or BHS techniques. Exposure to these techniques in training correlates with comfort level and plans to use them in independent practice.

Perspective Statement

This is the first survey published of US cardiothoracic surgical residents regarding off pump CABG in over 20 years. Exposure to OPCAB and BHS significantly correlated with future adoption of the technique by the CTSR. There does appear to be educational value in having an attending surgeon who performs routine OPCAB on the faculty of US training programs in cardiac surgery.
Glossary of Abbreviations

34 US- United States

35 OPCAB- off pump coronary artery bypass grafting

36 BHS- beating heart surgery

37 CTSR- cardiothoracic surgical residents

38 CABG- coronary artery bypass grafting

39 TSDA- Thoracic Surgery Director Association
Abstract

Background: We sought to determine the current level of exposure to, and interest in, off pump coronary artery bypass (OPCAB) and beating heart surgery (BHS) techniques regarding cardiothoracic surgical residents in the United States.

Methods: An email survey consisting of six questions was sent to all cardiothoracic surgery residents (CTSR) of approved cardiothoracic training programs in the United States. The survey was emailed using the Qualtrics XM cloud-based survey platform. When the email responses were received the answers to the survey questions were tabulated by the Qualtrics software and the resident’s institution and year of graduation from their residency was noted.

Results: Of 400 surveys sent, we received 99 responses for a response rate of 25%. 78% of CTSR reported that they are at programs that do OPCAB or BHS infrequently, noting that these cases are done in less than 5% of the CABGs to which they are exposed. 51% responded that they do not feel comfortable with off pump CABG under any circumstances. 49% reported some comfort with the technique with most of these respondents noting that they would do OPCAB or BHS on a selective basis if the clinical situation arose and 4% plan to do OPCAB routinely.

Exposure to OPCAB and BHS significantly correlated with future adoption of the technique by the CTSR. CTSR in the lowest, middle and highest terciles of exposure to OPCAB and BHS plan to use these techniques 31%, 86% and 75% respectively, in selective cases when they are in independent practice.

Conclusion: Over half of graduating CTSR do not feel comfortable with OPCAB or BHS techniques. Exposure to these techniques in training correlates with comfort level and plans to use them in independent practice.
Keywords: Coronary artery bypass grafting (CABG); cardiopulmonary bypass (CPB); surgical education; off-pump coronary artery bypass grafting (off-pump CABG); surgical myocardial revascularization
Introduction

Thirteen percent of coronary artery bypass (CABG) procedures in the United States were done off pump in 2016\(^1\). After 30 years of debate regarding off pump CABG (OPCAB) there has been a consensus among US surgeons that the reported long term decrease in graft patency\(^2,3\), the tendency towards incomplete revascularization\(^4,5\) and the technical challenges associated with OPCAB makes the technique inferior to on pump CABG for routine cases\(^6\). However, the avoidance of an aortic cross clamp in patients with calcified and atheromatous aortas\(^7\) and the avoidance of cardiopulmonary bypass in elderly patients\(^8\), patients with carotid disease\(^9,10\) or patients with elevated creatinine\(^11\) has shown to be of benefit. OPCAB also requires an experienced surgeon who is past the learning curve regarding exposure of target vessels and the use of stabilizers and other adjuncts to provide hemodynamic stability and allow for a technically perfect anastomosis.

In the 1990s and early 2000’s the popularity of OPCAB was at its height and a survey published by Ricci and associates\(^12\) reported that 98% of cardiothoracic surgical residents (CTSR) in the US were interested in doing CABGs off pump. Because of the popularity of the technique at that time many surgeons trained and performed OPCAB frequently and became proficient in the technique. As these surgeons retire, we wondered whether OPCAB and the techniques associated with it were becoming a ‘lost art’. We designed a survey that we sent to all CTSR in accredited US programs to assess the level of resident exposure to OPCAB, whether they were being trained in the technique and what they expected their future utilization of OPCAB would be when they finished training.
Methods

We sent an email survey to 400 CTSR in accredited US training programs as identified by the Thoracic Surgical Director Association (TSDA) roster. Our IRB reviewed the study (IRB #52000305, reviewed 8/19/2020) and it was exempt from IRB approval as outlined in federal regulations for protection of human services. The respondents were identified only by their email addresses, however the institution and level of training for each respondent was utilized as data points for our study. The survey is listed in Table 1 and was sent out in February of 2021 and included recent graduates who finished training in June of 2020. I-6 and residents in 4/3 programs who were in the third year of training or above were also sent the survey.

The survey was emailed using the Qualtrics XM cloud-based survey platform. Thoracic track residents were not identified as such on the TSDA roster and therefore were not excluded. The survey consisted of 6 questions regarding the experience and exposure the CTSR had to OPCAB and Beating Heart Surgery (BHS) during their training. When the email responses were received the answers to the survey questions were tabulated by the Qualtrics software and the resident’s institution and year of graduation from their residency was noted. In March of 2021 we sent out the survey out again to non-responders with corrected email addresses for as many CTSR as we could determine. Several Program Coordinators were emailed in order to get correct addresses if no resident from a particular training program responded.

The Qualtrics XM software allowed us to tabulate and graph the responses to questions 1-6. The “R Studio” software package allowed us to analyze the CTSR responses regarding their exposure and experience with OPCAB and BHS and how that correlated with their expected future utilization and adoption of these techniques. “R package ggplot2” software was utilized to generate stacked bar plots that correlated the reported exposure of the CTSR to OPCAB with
the future utilization of these techniques. Chi square analysis was used when comparing two
groups, when comparing three or more groups Fischer’s exact test was used.

Results
Of 400 surveys sent we received 99 complete responses. Fifty-one of seventy-five training
programs had at least one resident respond to our survey so that 68% of US cardiothoracic
training programs were represented in the survey by at least one respondent. The training
programs that had at least one resident respond to our survey are listed in Table 2.
The postgraduate level of training of the CTSR that responded is depicted in Table 3. 32% and
36% of respondents respectively were in the last one or two years of their training and 16% had
already completed their training.

78% of CTSR reported that they are at programs that do OPCAB or BHS very infrequently,
noting that these cases are done in less than 5% of the CABGs that they are exposed to. 14% of
CTSR were at programs where 10% to 25% of cases were done off pump and 9% of the
respondents were exposed to greater than 25% of CABGs off pump. As depicted in Figure 1A
we named these groups respectively: Group A (low exposure to OPCAB), Group B (medium
exposure to OPCAB) and Group C (high exposure to OPCAB).

Figure 1B shows that almost half of CTSR (48%) had no attendings at their training program that
performed OPCAB or BHS routinely. 29% of CTSR reported one attending surgeon available to
mentor them with regard to off pump cases. 23% of the survey respondents had two or more
attendings surgeons who did OPCAB.
Question #3 asked “if you are exposed to OPCAB do you perform the distal anastomosis” and
the results are shown in Figure 2A. 40% of CTSR report no exposure to OPCAB and 23% have
been exposed but have not performed a distal anastomosis off pump, indicating that they only
assisted the cases. 17% sometimes perform the distal anastomosis in an OPCAB case and 19%
usually perform the distal anastomosis or routinely act as primary surgeon.

Figure 2B shows the responses to question #4 regarding the teaching of the techniques for
exposure of the target vessels off pump. Most of the CTSR that responded (54%) were taught
exposure techniques for the circumflex and PDA off pump, while 46% were not.

Survey Question # 5 asked the CTSR about their experience with patients with heavily calcified
or atheromatous ascending aortas and whether they were exposed to OPCAB or BHS using
stabilizers, CO2 blowers or proximal anastomotic devices. As seen in Figure 2C, 31% of
respondents have not been exposed to any alternative CABG techniques during their training that
might avoid an aortic cross clamp. 40% of CTSR noted that they do use off pump techniques
when the aorta is “hostile” while 28% of CTSR noted that CABG cases are routinely done off
pump at their training program.

Figure 2D shows that when asked whether the CTSR plan to do OPCAB as attending surgeons
(Question #6) when they leave training, 51% responded that they do not feel comfortable with
off pump CABG under any circumstances. 49% reported some comfort with the technique with
most of these respondents noting that they would do OPCAB or BHS on a selective basis if the
clinical situation arose and 4% plan to do OPCAB routinely.

Figure 3A compares the CTSR assigned to Groups A, B and C based on their training programs
reported utilization of OPCAB and the respondents’ answers to Question # 6. 31% of CTSR in
Group A (low exposure to OPCAB) plan to use OPCAB in selective circumstances as attendings
while 86% of CTSR in Group B (medium exposure) and 75% of Group C (high exposure) plan
to use OPCAB and BHS selectively in the future. As seen in Figure 3A, the CTSR in groups B
and C had a significantly higher planned adoption rate of OPCAB in the future when compared
to Group A which reported less OPCAB exposure. All the CTSR that reported that they planned
to do OPCAB routinely when they finished their cardiothoracic residency (4/99) were in Group
C, the high exposure group.

Figure 3B shows how the effect of mentoring reflects the eventual adoption of OPCAB or BH
techniques. When there is no surgeon on the faculty of the training program only 23% of CTSR
plan to do OPCAB or BHS in the future compared to 75% of residents who have at least one
mentor for the technique. The presence of a mentor on the faculty is a significant predictor of
future OPCAB utilization (p<0.0001)

36% of the CTSR that reported that they have performed at least one distal anastomosis off pump
as surgeon and 23% reported exposure to OPCAB cases (assistant) without performing a distal
anastomosis. Figure 4 shows that 89% of the surgeon group and 39% of the assistant group plan
to utilize OPCAB techniques in the future compared to only 20% of CTSR who are unexposed to
OPCAB, indicating that operative experience is a significant determinant of the future adoption
of the technique.
Discussion

This is the first survey published of US cardiothoracic surgical residents regarding off pump CABG in over 20 years. We designed the survey to be a short six questions and we optimized the survey for handheld devices so that it could be completed in less than 5 minutes. We sent out multiple emails to non-responders and even emailed some Program Directors to try to encourage participation with the survey. We were disappointed with the 25% participation which is lower than the 53% response rate reported among physicians with other surgical surveys\textsuperscript{15}. Although we did have at least one response from 68% of the US training programs the 25% participation rate in our survey makes it hard to draw very accurate conclusions regarding the overall exposure and comfort level of current cardiothoracic surgical residents training in the US.

The attitudes regarding OPCAB that we report are markedly different from those Ricci et al.\textsuperscript{12} reported in 1999. In their study 98% of CTSR had some interest or great interest in OPCAB compared to the 50% of CTSR that stated they had no interest in performing OPCAB in our study. In 1999 the respondents reported that 93% had at least one Attending surgeon interested in OPCAB \textsuperscript{12} while in 2020 only 52% reported exposure to a mentor. Twenty years ago, 88% of CTSR expected to be doing OPCAB \textsuperscript{12} in their practice while only 44\% in our survey would use OPCAB selectively and another 4\% would use it routinely. We asked the residents specifically about their CABG experience with calcified and atheromatous aortas and found that most had received some training with avoiding an aortic cross clamp or using alternative anastomotic
techniques but 37% of respondents indicated that they had absolutely no off pump or beating heart experience in their training. Surprisingly 21% of these residents, with no exposure to beating heart surgery, answered survey question #6 that they would use OPCAB or beating heart techniques in selective circumstances as attendings, indicating a gap in their case experience during residency.

The main limitation of our study is the low response rate. In addition, we sent the survey to all the US residents that we could identify from the TSDA email list regardless of whether the resident was in the cardiac or thoracic track. Although most responses were from residents within 2 years of completing their training (84%) we did not exclude respondents in the thoracic track. We presume that non cardiac track residents and junior residents that had minimal operative experience with cardiac cases were among the 75% of CTSR that did not participate in the survey, but we have no way of verifying this. 15% of respondents had 3 or more years until completion of their residency (Table 3) implying that they were not likely to perform any distal anastomoses or be taught off pump techniques. Since half of the survey questions dealt with mentoring and teaching as well as the training programs’ overall experience with off pump surgery, we feel that the small number of junior residents that answered the survey does not affect the validity of our findings.

The survey was conducted in February 2021 just as the Covid vaccinations were offered to the general population in the US and nine months after the nadir of cardiac surgical case volumes that occurred in April of 2020. Dr. Nguyen and associates have documented a 51.2% drop in isolated CABG cases in the US in April 2020 but volumes increased back up to 87% of pre
pandemic levels by July of 2020. We feel that this brief but dramatic decrease in case volumes had little effect on the overall CABG experience and the exposure to off pump CABG of our respondents during this time.

Much has been written in the previous decade regarding teaching of OPCAB to residents so that they are proficient in the technique and perform OPCAB safely. These papers outline a gradual progression of the resident doing distal anastomosis on the LAD and diagonal vessels initially. As they gain experience, residents perform the distal anastomosis to the vessels on the inferior wall and finally the circumflex branches which are the most challenging to expose.

Over half the respondents in our survey report that they were exposed and taught these techniques with 19% of the residents acting as primary surgeon on these cases.

Not surprisingly our stacked bar plot analysis did show that the CTSR who were exposed to off pump surgery in their residency programs were much more comfortable with the technique (figure 3A). Half (4/8) of the residents from programs that reported performing over 25% of the CABGs off pump expected to do OPCAB routinely as attendings. Analysis of the survey data showed that CTSR who had at least one attending to mentor them in OPCAB techniques and who had performed a distal anastomosis as surgeon were significantly more likely to utilize OPCAB in the future as an attending compared to others. (Figures 3B and 4).

In summary, our study suggests that half of the current cardiothoracic surgical residents in the US have minimal exposure to OPCAB or beating heart surgery and do not plan to use these techniques in their future practices. Approximately 50% of CTSR in the US in 2021 are being taught OPCAB techniques and have a mentor at their training program. About one third of CTSR have performed a distal anastomosis off pump and approximately 20% of the residents who
responded to this survey have acted as primary surgeon on an OPCAB case. This would suggest that OPCAB in the US will continue to be performed at least at the current level and that US cardiothoracic residency programs are training some graduates to do OPCAB without the need for additional surgical revascularization fellowships. There does appear to be educational value in having an attending surgeon who performs routine OPCAB on the faculty of US training programs in cardiac surgery. Perhaps offering more exposure during their cardiothoracic residency to the 50% of CTSR who are unexposed to OPCAB might minimize the need for additional postgraduate training for off pump CABG.
References


Legends

**Figure 1A:** Group A residents were at programs that had low exposure to OPCAB (<5% of CABG off pump). Those in Group B where 10% to 25% of cases were done off pump were considered medium exposure to OPCAB and the residents who reported exposure >25% of CABGs off pump

**Figure 1B:** Almost half of the CTSR that responded have no Attending surgeon that performs OPCAB routinely while 52% do have at least one Attending who performs OPCAB.

**Figure 2A:** Question #3: 40% of CTSR reported zero exposure in their residency to OPCAB. 23% of the respondents have assisted on OPCAB but have not performed a distal anastomosis off pump. 19% of respondents perform the distal anastomosis for OPCAB routinely in their training program.

**Figure 2B:** Question #4: 18% of the respondents reported that they had not only been taught the techniques for exposure of the circumflex branches and PDA, but they had acted as the surgeon OPCAB cases. 36% of CTSR were taught the techniques but only assisted while 46% were not taught these techniques for OPCAB at all.

**Figure 2C:** Question #5: 31% of CTSR reported no exposure to OPCAB at all, while 28% have routine exposure. 40% of respondents are exposed to OPCAB in selective situations.

**Figure 2D:** Question #6: 51% of respondents do not feel comfortable with OPCAB and do not plan to use the technique in their practice as Attendings. 45% of CTSR do plan to use OPCAB selectively in the future while 4% of CTSR plan on doing OPCAB routinely as Attendings.

**Figure 3A:** 39% (30/77) of CTSR in The Low Exposure (Group A) plan do to OPCAB as Attendings. 86% (12/14) of the CTSR in Group B (medium exposure) plan OPCAB selectively and 87% (7/8) of Group C (high exposure) plan on doing OPCAB. 50% of group C plan routine OPCAB

**Figure 3B:** When the training programs have at least one Attending performing OPCAB routinely 73% of residents plan to utilize OPCAB selectively in the future compared to only 23% of CTSR without a mentor in their program

**Figure 4:** 86% of residents that have acted as surgeon on an OPCAB distal anastomosis plan on performing OPCAB as Attendings. This is significantly more than the 43% that have only assisted and the 20% that had no exposure.
**TABLE 1. Survey Questions**

1. What percentage of CABGs in your training were done either off pump or beating heart with pump assist?
   - a. 0
   - b. <5%
   - c. Approximately 10%
   - d. 10-25%
   - e. 26-50%
   - f. >50%

2. How many attending surgeons, with whom you train, perform off pump or beating heart CABG routinely?
   - a. 0
   - b. 1
   - c. 2
   - d. >2

3. If you are exposed to OPCAB, are you performing the distal anastomosis?
   - a. I am not exposed to OPCAB techniques
   - b. I am exposed but do not perform the distal anastomosis
   - c. Sometimes I do the distal anastomosis
   - d. Most of the time I perform the distal anastomosis
   - e. I stand on the surgeon’s side and I am the primary surgeon on OPCABs

4. Have you been taught the techniques for exposure of various targets including the PDA and circumflex branches?
   - a. No, I have not been taught
   - b. I have been taught but I only assist
   - c. I have been taught and done several cases as primary surgeon

5. Do the attending surgeons use off pump techniques and equipment either with, or without, cardiopulmonary bypass (stabilizers, CO2 blowers, proximal anastomotic devices) when they encounter calcified or atheromatous aortas during a CABG when a cross clamp might be contraindicated?
   - a. Never, I have not been exposed
   - b. We do OPCAB or beating heart if the ascending aorta or arch is hostile
   - c. One or more of my attendings do OPCAB routinely

6. Do you expect to do OPCAB as an attending when you leave your training program?
   - a. No, I do not feel comfortable with these techniques
   - b. I plan on doing off pump or beating heart CABG occasionally, in selected cases
   - c. I plan on doing OPCAB electively when I leave training
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Experience with Distal Anastomosis compared to Plans for Future Utilization

![Bar chart showing the number of respondents for different levels of exposure and plans for future utilization of distal anastomosis techniques.]

- No exposure: 32 respondents
- Resident assist: 10 respondents
- Resident surgeon: 27 respondents

**Legend:**
- Red: No I do not feel comfortable with these techniques
- Green: I plan on doing off pump or beating heart CABG occasionally
- Blue: I plan on doing OPCAB electively when I leave training

* p = 0.09
** p = 0.001
*** p = 3 x 10^{-8}

Resident Experience with Distal Anastomosis in OPCAB
A Q1: What percentage of CABGs in your training were done either off pump or beating heart with pump assist?

Institutional Utilization

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<td>B</td>
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<tr>
<td>C</td>
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B Q2: How many attending surgeons, with whom you train, perform off pump or beating heart CABG routinely?

Number of Attendings

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A. Q2: If you are exposed to OPCAB are you performing the distal anastomosis?

- I stand on the surgeon's side and I am the primary surgeon on OPCAB: 10 respondents
- Most of the time I perform the distal anastomosis: 19 respondents
- Sometimes I do the distal anastomosis: 23 respondents
- I am exposed but do not perform the distal anastomosis: 40 respondents
- I am not exposed to OPCAB techniques: 0 respondents

B. Q4: Have you been taught the techniques for exposure of various targets including the PDA and circumflex branches?

- I have been taught and done several cases as primary surgeon: 15 respondents
- I have been taught but I only assist: 35 respondents
- No, I have not been taught: 45 respondents

C. Q5: Do the attending surgeons use off pump techniques and equipment either with, or without, cardiopulmonary bypass (stabilizers, CO2 blowers, proximal anastomotic devices) when they encounter calcified or atheromatous sortas during a CABG when a cross clamp might be contraindicated?

- One or more of my attendings do OPCAB routinely: 28 respondents
- We do OPCAB or beating heart if the ascending aorta or arch is hostile: 40 respondents
- Never, I have not been exposed: 50 respondents

D. Q6: Do you expect to do OPCAB as an attending when you leave your training program?

- I plan on doing OPCAB electively when I leave training: 4 respondents
- I plan on doing off pump or beating heart CABG occasionally: 64 respondents
- No I do not feel comfortable with these techniques: 50 respondents
Institutional Utilization of OPCAB compared to Plans for Future Utilization

A

Number of respondents

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- No I do not feel comfortable with these techniques
- I plan on doing off pump or beating heart CABG occasionally
- I plan on doing OPCAB electively when I leave training

- * p = 0.0029
- ** p = <0.0001
- *** p = <0.0001

Institutional Utilization of OPCAB

Number of attendings performing OPCAB compared to Plans for Future Utilization

B

Number of respondents

<table>
<thead>
<tr>
<th>Number of Attendings Performing OPCAB</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>n=36</td>
</tr>
<tr>
<td>1</td>
<td>n=11</td>
</tr>
<tr>
<td>2</td>
<td>n=18</td>
</tr>
<tr>
<td>&gt;2</td>
<td>n=7</td>
</tr>
</tbody>
</table>

- No I do not feel comfortable with these techniques
- I plan on doing off pump or beating heart CABG occasionally
- I plan on doing OPCAB electively when I leave training

- * p = <0.0001
- ** p = <0.0001
- *** p = 0.0056

Number of attendings performing OPCAB
Experience with Distal Anastomosis compared to Plans for Future Utilization

- Red: No I do not feel comfortable with these techniques
- Green: I plan on doing off pump or beating heart CABG occasionally
- Blue: I plan on doing OPCAB electively when I leave training

<table>
<thead>
<tr>
<th>Experience with Distal Anastomosis in OPCAB</th>
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</thead>
<tbody>
<tr>
<td>Resident Experience with Distal Anastomosis in OPCAB</td>
</tr>
</tbody>
</table>

- * p = 0.09
- ** p = 0.001
- *** p = 3 x 10^-6