

Surgeons' Preference for Off-Pump or On-Pump Coronary Artery Bypass Grafting Surgery

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ABSTRACT

Background: Surgeon's preference is an important factor in clinical strategy for off-pump (OPCAB) or on-pump (ONCAB) coronary artery bypass graft (CABG) surgery. This study analyzed surgeons' understanding of and propensity for both techniques.

Methods: A survey was performed by self-reported questionnaire. Two sections were included: Q1 questionnaire investigated each surgeon's opinion on the indications of OPCAB and ONCAB; and Q2 questionnaire investigated each surgeon's choice of OPCAB or ONCAB in different clinical situations.

Results: The questionnaires were sent to 169 surgeons. In Q1, 71.2% of surgeons indicated that the degree of overlap between the indications of OPCAB and ONCAB is >70%; 55.1% believed that OPCAB had a wider scope of indications than ONCAB, and 35.3% believed that ONCAB had a wider scope of indications than OPCAB. In Q2, >70% of surgeons who responded chose OPCAB for patients with the following characteristics: high risk of stroke, renal dysfunction, pulmonary dysfunction, malignancy, clotting and coagulation disorders, or age ≥80 years. More than 57.5% of surgeons chose ONCAB for patients with poor target vessels or ventricular enlargement and dysfunction. For novice surgeons, 87.5% of surgeons chose ONCAB.

Conclusion: Most surgeons surveyed agreed that OPCAB and ONCAB are suitable for most patients; however, surgeons' preference for ONCAB or OPCAB varied. Surgeons are more willing to choose ONCAB in the presence of complicated heart conditions and OPCAB in the presence of serious concomitant diseases.

INTRODUCTION

In spite of the coexistence of off-pump (OPCAB) and on-pump (ONCAB) coronary artery bypass surgery for many years, current evidence is inconclusive regarding their pros

and cons. Some well-designed trials, such as ROOBY and CORONARY, reported that OPCAB had no clinical advantages over ONCAB and even increased the risk of major adverse cardiovascular events or repeat revascularization [Lamy 2016; Shroyer 2017; Hu 20210]. Correspondingly, several large propensity-matched retrospective series and meta-analyses from centers proficient in OPCAB provided evidence in favor of this technique in decreasing risk of death, stroke, acute renal failure, mortality, morbidity, and postoperative length of stay compared with ONCAB [Polomsky 2013; Kowalewski 2016]. Thus, how to make a reasonable choice is a constant clinical question.

Patients routinely accept the surgeon's preferred technique for performing coronary artery surgery [Nishith 2011]. Therefore, a surgeon has to choose OPCAB or ONCAB for individual patients based on the surgical strategy. The choice depends on the patient's coronary artery lesions and comorbidities, the team's ability, some social and economic situations, and most important, the surgeon's training and proficiency in the 2 techniques. This strategy, even for a specific patient, varies by surgeon, institution, and region.

Previous studies mostly focused on skills and outcomes in OPCAB and ONCAB, rather than surgeon preference. Thus, we surveyed the subjective intention of cardiac surgeons about the indications for OPCAB and ONCAB, as well as their preferences for each technique in different clinical settings.

MATERIALS AND METHODS

Study Population

We undertook a cross-sectional, self-reported questionnaire survey of 169 registered cardiac surgeons from China.

Survey Instrument

The questionnaire included 2 parts: Q1 and Q2. Q1 aimed to investigate the surgeon's opinion about the indications for OPCAB and ONCAB (Figure 1). Q2 aimed to investigate the surgeon's choice of OPCAB or ONCAB in different clinical situations (Figure 2).

Administration of the Survey

Each of the surgeons surveyed was contacted individually by an investigator, to ensure that each surgeon completed the survey only once. Other than the content of the questionnaire itself, the investigator did not undertake any additional explanation.

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There were 2 types of surveys: for on-site investigation, questionnaires were filled out and collected on the spot through academic meetings or hospital visits; and for mobile surveys, the investigator contacted the surgeon through instant messaging software, directly issued questionnaires, and collected the answers.

Statistical Analysis

Excel 2010 and SPSS 18.0 statistical software were used for data collation and statistical processing. The composition ratio was used as the main statistical index for descriptive analysis, and χ^2 test was used for comparison between groups. $P < .05$ was considered statistically significant.

RESULTS

Results of Q1

A total of 156 valid Q1 questionnaires were collected. Four groups were defined according to the number of independent surgeries performed: 69 surgeons in group I had not

yet performed the surgery independently, 26 in group II had performed 1 to 50 independent surgeries, 42 in group III had performed 51 to 2000, and 19 in group IV had performed >2000.

Results on the Degree of Overlap between ONCAB and OPCAB Indications

The B value, defined as the degree of overlap between the indications for the 2 surgical methods, represents the proportion of patients who are suitable for both ONCAB and OPCAB. Most surgeons (97.4%; 152 of 156) did not choose the option

Dear surgeon:

Thank you for taking part in this anonymous questionnaire survey on the surgical methods of coronary artery bypass grafting.

Before the investigation start, please confirm:

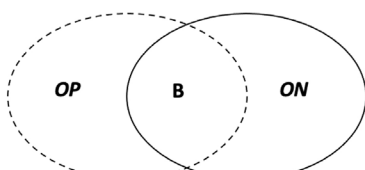
1. You are a cardiac surgeon;
2. This is your first time to fill in this questionnaire.

The abbreviations are as follows:

OPCAB: Off-pump coronary artery bypass grafting

ONCAB: On-pump coronary artery bypass grafting

Q1 The indications of OPCAB and ONCAB for patients undergoing isolated primary multi-vessel coronary artery bypass grafting.



Notes:

Left dotted circle: the indications of OPCAB

Right solid circle: the indications of ONCAB

OP: Suitable for OPCAB, but not suitable for ONCAB

B: Suitable for **both** OPCAB and ONCAB

ON: Suitable for ONCAB, but not suitable for OPCAB

1. According to your understanding, which percentage of the following is B closest to?
a. 100% b. 90% c. 70% d. 50% e. 30% f. 10% g. 0%
2. According to your understanding, the relationship between OP and ON is ____?
a. $OP > ON$ b. $OP = ON$ c. $OP < ON$
3. How many cases of coronary artery bypass have you performed independently?
a. 0 case b. 1-50 cases c. 51-500 cases d. 501-2000 cases e. >2000 cases

Figure 1. The Q1 questionnaire.

Dear surgeon:

Thank you for taking part in this anonymous questionnaire survey on the surgical methods of coronary artery bypass grafting.

Before the investigation start, please confirm:

1. You are a cardiac surgeon;
2. This is your first time to fill in this questionnaire.

The abbreviations are as follows:

OPCAB: Off-pump coronary artery bypass grafting

ONCAB: On-pump coronary artery bypass grafting

Q2: Under the following circumstances, which technique do you prefer to choose?

A. OPCAB B. ONCAB C. no difference between the two

	A	B	C
1. Patients with mild or moderate renal insufficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Dialysis-dependent patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Patients at high risk of stroke	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Patients with chronic obstructive pulmonary disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Patients with cardiomegaly and ejection fraction < 40%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Multiple diffuse lesions or relatively small coronary vessels	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Severe left main lesion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. When an endarterectomy is required	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Multiple total arterial revascularization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. intra-myocardial vessels	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. octogenarian patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Very obese patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Patients combined with malignancy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Patients with clotting and coagulation disorders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Blood shortage or rejection of allogeneic transfusion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. Novice surgeons in coronary surgery	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 2. The Q2 questionnaire.

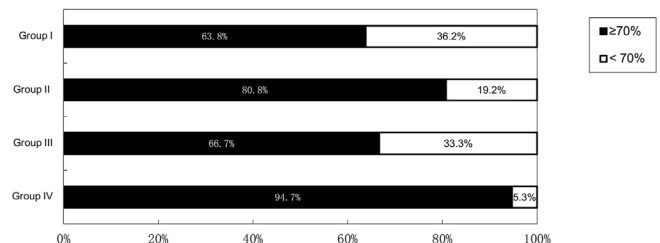


Figure 3. The B value between groups in Q1. B value represents the proportion of patients who are suitable for both OPCAB and ONCAB.

of 100% for the B value, thus believing that the indications for OPCAB and ONCAB did not fully overlap. Those who chose a B value $\geq 70\%$ accounted for the majority of all surgeons (71.2%), and each group showed a similar trend (Figure 3).

Among groups, there were significant differences between surgeons with different volumes of surgery experience ($P = .036$). In group IV, more surgeons (94.7%) chose a B value $\geq 70\%$ (Table 1), and the χ^2 test of Mantel-Haenszel showed a trend of linear correlation between an increase in operation volume and a larger B value ($P = .050$).

Results on the Scope of ONCAB and OPCAB Indications

Regarding the scope of OP and ON indications, $OP > ON$ means OPCAB has a wider scope of indications than ONCAB, $OP < ON$ means ONCAB has a wider scope of indications than OPCAB, and $OP = ON$ means the same scope of indications for both. In response to this survey question, more surgeons (55.1%) chose $OP > ON$, and thus believed that OPCAB had a larger suitable population of patients. This tendency could be found in each group and did not differ significantly between groups ($P = .818$) (Table 2; Figure 4).

Results of Q2

A total of 120 valid Q2 questionnaires were collected. More than 70% of surgeons surveyed were inclined to choose

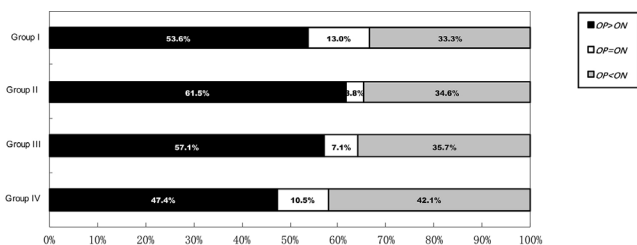


Figure 4. The relationship between OP value and ON value in Q1. OP and ON represent the scope of OPCAB and ONCAB indications, respectively.

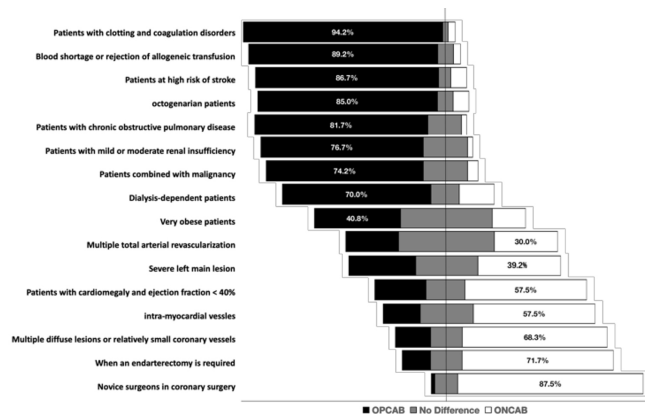


Figure 5. Surgeon preferences for OPCAB and ONCAB in different clinical conditions.

OPCAB when patients had more concurrent diseases such as high risk of stroke, renal dysfunction, pulmonary dysfunction, malignancy, and clotting and coagulation disorders or were octogenarians. More than 57.5% of surgeons surveyed were inclined to choose ONCAB when the difficulties and challenges of surgery were focused on the heart itself, such as poor target vessels and ventricular enlargement and dysfunction. One of the noteworthy results was that for novice surgeons, the choice of ONCAB achieved a very high consensus (87.5%) (Figure 5).

DISCUSSION

Coronary surgery has a history of >60 years, during which ONCAB has been the dominant approach. For >20 years, the OPCAB approach has aimed to improve the outcome of coronary artery bypass surgery by reducing the damage caused by extracorporeal circulation. However, there has been insufficient evidence to prove the relative merits of either approach [Lamy 2016]. Whether OPCAB and ONCAB are applicable to the same or different types of patients remains to be further explored.

In this study, most surgeons agreed that indications for the 2 techniques partially overlap (B value), but are not completely superimposable (OP value and ON value), which suggests that neither of the techniques can handle all practical clinical situations. This is consistent with some of the cases that we envision encountering, such as severe aortic calcification or hemodynamic instability. In our survey, most surgeons believed that OPCAB and ONCAB have different scopes of indications, and that OPCAB expands the indications of traditional on-pump technique, but there are still a need for ONCAB that OPCAB cannot meet. Accordingly, surgeons should consider more of the factors (OP or ON values) that cannot be fully covered by a technique and comprehend the limitations of one technique and the advantages of the other. Being aware of this may help surgeons to make rational strategic choices.

The B value of Q1 represents the overlap range of OPCAB and ONCAB indications, which may largely depend on the

Table 1. The B Value between Groups in Q1*

Group	n	$\geq 70\%$	$< 70\%$	P Value
I	69	44 (63.8)	25 (36.2)	
II	26	21 (80.8)	5 (19.2)	
III	42	28 (66.7)	14 (33.3)	
IV	19	18 (94.7)	1 (5.3)	
Total	156	111 (71.2)	45 (28.8)	.036

*Data are n (%) unless noted otherwise. Group I, surgeons without independent surgical experience; group II, surgeons with 1 to 50 cases; group III, surgeons with 51 to 2000 cases; and group IV, surgeons with >2000 cases. B value represents the proportion of patients who are suitable for both OPCAB and ONCAB.

surgeon's training experience and surgical ability. Many studies have proposed that OPCAB training and operation volume have a great influence on the clinical outcomes of OPCAB [Taggart 2020]. Surgeons who have received more OPCAB training and performed more OPCAB operations may be more inclined to choose OPCAB as the surgical strategy for a new patient. For surgeons with less OPCAB training and less surgery experience, ONCAB is obviously a favorite option. However, it should be emphasized that this only an explanation of the differences between the techniques, not a direct reflection of the effectiveness of treatment. In the questionnaire results, we also noticed a trend that surgeons with >2000 surgeries chose a larger range of B values, whereas those without independent surgery chose a relatively small range of B values. More specific evidence is that the ONCAB option in Q2 for novice surgeons accounted for 87.5%, reaching first place among all reasons for ONCAB selection.

Although surgeons subjectively believe that OPCAB or ONCAB can be applied to most patients, the choice between OPCAB and ONCAB may be controversial for patients in special subgroups or under special clinical conditions. Q2 was designed to investigate these possibly controversial issues. The descriptive results reflect the tendency of surgeons to opt for OPCAB surgery in patients with severe comorbidities and complex clinical conditions and for ONCAB surgery in patients with complex cardiac conditions. However, the consistency between subjective knowledge and objective evidence is also worth discussing. For example, the surgeons in this study were subjectively inclined to choose OPCAB surgery for elderly patients (≥ 80 years), whereas the randomized results of the GOPCABE trial showed no difference between OPCAB and ONCAB surgery in 5-year survival rates, myocardial infarction, or revascularization in elderly patients [Diegeler 2019].

Another controversial example is the case of severe left main lesion, in which surgeons' opinions were scattered, and the selection of all options were almost equal in number. The EXCEL study, in contrast, clearly stated that OPCAB increased 3-year all-cause mortality in patients with left main lesion [Benedetto 2019]. Other controversial questions in Q2 may also be points of interest and need more objective evidence to confirm.

Experts admit that the choice between OPCAB and ONCAB is an individualized experience, a combination of a surgeon's technical proficiency and outcome cognition [Puskas 2019]. The results of this study—including the range of B values, the relationship between OP and ON, and the choice of doctors in different clinical situations—fully illustrate the enthusiasm of the surveyed doctors for OPCAB surgery. If a technique is considered to be difficult and challenging, surgeons would be motivated to pursue it if its outcome is not inferior. In other words, OPCAB, which is considered to be more technically difficult, will still be popular with surgeons, and the current evidence does not clearly suggest its superiority over ONCAB.

The limitations of this study are mainly in 2 aspects. First, the surgeons surveyed are only from China. It is known that the ratio of OPCAB to ONCAB in Asian countries is significantly higher than in Europe and the United States, which may make the survey results biased to OPCAB. Second, some misunderstanding of the topics or questions is possible, leaving a small number of surgeons surveyed struggling with options such as "I can do" versus "I should do," and balancing surgical ability and clinical outcomes.

CONCLUSIONS

Most surgeons surveyed in this study agreed that OPCAB and ONCAB are suitable for most patients. However, the overlap of the indications between OPCAB and ONCAB varied among surgeons with different volumes of surgical experience. More surgeons with a large volume of surgery (>2000 cases) recognized that the overlap is relatively large. As for the scope of indications for the 2 operations, more surgeons believed that OPCAB indications are more extensive. On a subjective level, surgeons are more willing to choose ONCAB when there are adverse factors related to the heart itself, such as poor target vessels or ventricular enlargement and dysfunction. OPCAB is preferred by surgeons in the presence of more serious concomitant factors, such as advanced age, high risk of stroke, renal dysfunction, pulmonary dysfunction, malignancy, and clotting and coagulation disorders. For beginners in coronary surgery, ONCAB is preferred.

Table 2. The Relationship between OP Value and ON Value in Q1*

Group	n	OP > ON	OP = ON	OP < ON	P Value
I	69	37 (53.6)	9 (13.0)	23 (33.3)	
II	26	16 (61.5)	1 (3.8)	9 (34.6)	
III	42	24 (57.1)	3 (7.1)	15 (35.7)	
IV	19	9 (47.4)	2 (10.5)	8 (42.1)	
Total	156	86 (55.1)	15 (9.6)	55 (35.3)	.818

*Data are n (%) unless noted otherwise. Group I, surgeons without independent surgical experience; group II, surgeons with 1 to 50 cases; group III, surgeons with 51 to 2000 cases; and group IV, surgeons with >2000 cases. OP and ON represent the scope of OPCAB and ONCAB indications, respectively.

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