Meta-analysis on the use of the Heartstring anastomotic device to prevent stroke in patients undergoing off-pump coronary artery bypass grafting

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Abstract

Objective: Postoperative stroke is the Achilles’ heel of coronary artery bypass surgery compared with percutaneous coronary intervention. In this meta-analysis, we sought to determine the efficacy of the Heartstring proximal anastomotic device to reduce the risk of postoperative stroke after off-pump coronary artery bypass grafting (OPCAB). Methods: Studies on the Heartstring device were identified by searching PubMed, Cochrane Library and Scopus up to November 2010. The results were expressed as pooled proportions (%) with 95% confidence interval (95% CI). Heterogeneity across the studies was evaluated by the I² test and a random effects model was used. Results: Eighteen articles were pertinent with this issue and we were able to retrieve data on the Heartstring anastomotic device in OPCAB from eight studies. Three studies were prospective and routine epi-aortic ultrasound was used in three studies. A total of 819 patients were enrolled in these eight studies and six of them suffered stroke postoperatively. Cumulative analysis showed a pooled rate of immediate postoperative stroke after OPCAB with the use of Heartstring of 1.9% (95% CI 0.8–4.5, I² = 23%). Sensitivity analysis including the only three studies evaluating patients with diseased ascending aorta as detected at epi-aortic ultrasound showed that a pooled rate of stroke was 3.2% (95% CI 0.8–11.9, I² = 0%). Six studies reported on immediate postoperative mortality and the pooled mortality rate was 1.9% (95% CI 0.1–3.4). Conclusions: The results of this meta-analysis suggest that the risk of stroke after OPCAB may not be markedly reduced by the use of Heartstring device. On the other hand, a rather low rate of stroke was observed among patients with diseased ascending aorta indicating its potential value in these patients. Most of studies included in this meta-analysis were of poor methodological quality, and properly conducted prospective studies are needed to get more conclusive results on the safety and efficacy of Heartstring anastomosis device.

Keywords: Coronary artery bypass surgery; Stroke; Anastomosis device; Heartstring

1. Introduction

The SYNergy between percutaneous coronary intervention with TAXus and cardiac surgery (SYNTAX) trial has shown that postoperative stroke is the Achilles’ heel of coronary artery bypass (CAB) surgery when compared with percutaneous coronary intervention [1]. Indeed, a meta-analysis showed that procedure-related stroke risk was higher in patients undergoing CAB surgery than in those undergoing percutaneous coronary intervention (1.2% vs 0.6%, p = 0.002) [2]. This suggests that more research and different treatment approaches are needed to prevent neurological complications after coronary artery bypass surgery. Meta-analysis of randomized studies reported a cumulative incidence of postoperative stroke ranging from 0.5% to 1.6% [3,4], whereas observational studies including large series reported slightly higher stroke rates, but still ranging from 1.2% to 2.5% [5–8]. Off-pump surgery (OPCAB) seems to reduce the risk of postoperative stroke, but unequivocal evidence is lacking because of potentially different surgical approaches toward prevention of stroke during either OPCAB or conventional CAB surgery [5]. Avoidance of manipulation of diseased ascending aorta may be a key issue to significantly decrease the risk of postoperative stroke after OPCAB [9,10], but a policy of routine epi-aortic ultrasound screening and no-touch aorta technique in cases with severely diseased aorta is not embraced by all surgeons [5]. As diseased ascending aorta can be encountered in nearly 30% of patients undergoing CAB [11], identification of this condition and strategies to prevent embolism from diseased ascending aorta are indicated.

The Heartstring device (Guidant, Indianapolis, USA) has been developed to accomplish proximal anastomosis to the ascending aorta with minimal aortic manipulation, and has been suggested to prevent atherosclerosis debris embolization in these high-risk patients. The safety and efficacy of this device to prevent postoperative stroke has been assessed in this meta-analysis of currently available clinical studies.

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2. Material and methods

An English-language literature review was performed through PubMed, Cochrane Library and Scopus up to November 2010 for any research evaluating the safety and efficacy of the Heartstring proximal anastomosis device in patients undergoing OPCAB. The decision to limit the present study only to studies evaluating OPCAB was due to the possibility of 'no-touch aorta' offered by this technique. The words employed in the search were 'Heartstring' and 'anastomosis device.' Books as well as cardiovascular surgery journals have been searched. Furthermore, we searched for ongoing or completed studies on this issue in Clinicaltrials.gov.

Only prospective and retrospective observational studies published in English language as full article with all details of methods and results have been considered for this analysis. Outcome end points were reported as originally defined by the authors.

Stroke is the main outcome end point of this study. Secondary outcome end points, such as in-hospital/30-day postoperative death, postoperative myocardial infarction and graft patency at discharge were assessed for analysis. Transient ischemic attack was not considered an outcome end point in this study.

2.1. Data collection and analysis

The authors independently abstracted data from all eligible studies using a standardized Excel file. They retrieved data on study design, study size, patient demographics, type of intervention, and any outcome end points. Data were retrieved only from the articles, and no attempt was made to get missing data from the authors.

The results were expressed as pooled proportions (%) with 95% confidence interval (95% CI). Heterogeneity across the studies was evaluated using the I² test. Because heterogeneity was anticipated among the observational studies, it was assessed a priori by a random effects model (DerSimonian–Laird). Sensitivity analysis was planned but eventually not carried out because of the small number of studies retrieved for analysis. Statistical analysis was performed using Metaanalyst Beta 3.13 software (http://tuftsca.org/meta_analyst/) [12].

3. Results

The search yielded 18 articles, which were pertinent with this issue and potential sources of information on patients undergoing CABG using the Heartstring device. The search flowchart is shown in Fig. 1. The search in Clinicaltrials.gov yielded one study on Heartstring, which is still recruiting since 2006 and its results are, to our knowledge, still unpublished. We were able to retrieve data on the use of the Heartstring anastomotic device in coronary artery bypass grafting (CABG) from eight studies [13–20]. Among these studies, only two were of prospective nature. One major limitation of these studies was the lack of routine epi-aortic ultrasound in five out of eight studies. Characteristics and results of these studies are summarized in Table 1.

![Fig. 1. Flow-chart summarizing literature search results for studies dealing with Heartstring proximal anastomosis device. OPCAB: off-pump coronary artery bypass grafting.](https://academic.oup.com/ejcts/article-abstract/40/5/1236/448290)

A total of 819 patients were retrieved from these eight studies and six of them suffered of stroke after surgery. Cumulative analysis showed a pooled rate of immediate postoperative stroke after OPCAB with the use of the Heartstring of 1.9% (95% confidence interval (CI) 0.8–4.5, I² = 23%, Fig. 2). Sensitivity analysis including the only three studies evaluating patients with diseased ascending aorta as detected at epi-aortic ultrasound showed that the pooled rate of stroke was 3.2% (95% CI 0.8–11.9, I² = 0%). Five studies reported on the use of blower and their pooled stroke rate was 2.1% (95% CI 0.7–6.8, I² = 6.7%, 1 patient out of 317 patients).

Six studies reported on immediate postoperative mortality (9 patients out of 729) and the pooled mortality rate was 1.9% (95% CI 0.1–3.4, I² = 0%, Fig. 3).

Five studies reported on postoperative myocardial infarction (7 patients out of 483) and its pooled rate was 1.8% (95% CI 0.9–3.6, I² = 0%).

![Fig. 2. Forest plot for stroke rates after off-pump coronary artery bypass grafting with the use Heartstring proximal anastomosis device. The pooled stroke rate was 1.9% (95% CI 0.8–4.5), I² = 23%](https://academic.oup.com/ejcts/article-abstract/40/5/1236/448290)
Table 1: Summary of data of eight studies evaluating the use of Heartstring proximal anastomotic device in preventing postoperative stroke in patients undergoing isolated coronary artery bypass surgery.

<table>
<thead>
<tr>
<th>Author</th>
<th>Study period</th>
<th>Study design</th>
<th>No. of patients</th>
<th>OPCAB</th>
<th>No. of proximal anastomoses with Heartstring (%)</th>
<th>Technical secretion to aortic clamp used</th>
<th>Use of epiaortic ultrasound</th>
<th>No. of patients with Heartstring ultrasound</th>
<th>Postoperative stroke (%)</th>
<th>Postoperative mortality (%)</th>
<th>Overall mortality (%)</th>
</tr>
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<tr>
<td>Modabber, 2008</td>
<td>2004—2007</td>
<td>NS</td>
<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
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<td>Biancari, 2006</td>
<td>2004—2005</td>
<td>NS</td>
<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
<tr>
<td>Schoettle, 2007</td>
<td>2004—2005</td>
<td>NS</td>
<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
<tr>
<td>Guerrieri Wolf, 2007</td>
<td>2004—2007</td>
<td>NS</td>
<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
<tr>
<td>Hilsenrath, 2007</td>
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<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
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<td>0.000 (0.000, 0.000)</td>
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<tr>
<td>Sakopoulos, 2007</td>
<td>2004—2007</td>
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<td>12</td>
<td>50/100</td>
<td>19/100</td>
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<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>NS</td>
<td>12</td>
<td>50/100</td>
<td>19/100</td>
<td>NS</td>
<td>Yes</td>
<td>Yes</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0.000 (0.000, 0.000)</td>
</tr>
</tbody>
</table>

In parentheses are percentages. OPCAB: off-pump coronary artery bypass surgery; NS: not stated.

Fig. 3. Forest plot for immediate mortality rates after isolated CABG with the use Heartstring proximal anastomosis device. The pooled mortality rate was 1.9% (95% CI 0.1—3.4), I² = 0%.

No data on graft patency were available in these studies.

4. Discussion

Early stroke after isolated CABG is a severe complication, which is associated with increased risk of early and late mortality [7]. As the impact of carotid artery disease on the development of postoperative stroke could be not significant, particularly during OPCAB [21], stroke occurring mostly during the first postoperative hours/days should be considered a complication related to aortic manipulation as well as use of cardiopulmonary bypass [5]. A number of strokes may occur also a few days after surgery as the result of atrial fibrillation, myocardial infarction and/or coagulopathy [8,22], and, not infrequently, affect patients with yet a complicated postoperative course. However, the real nature of these late strokes is undetermined. It has been observed that OPCAB is associated more frequently with late strokes [8]. As OPCAB may lead to late thrombin generation and reduced fibrinolysis as well as higher platelet activity during the immediate postoperative period, we can speculate that such delayed strokes occurring a few days after surgery may be secondary to an unexpected pronounced platelet aggregation.

While strokes occurring a few days after surgery can be prevented by anticoagulation, early stroke can be mostly prevented by a policy of routine and carefully performed epiaortic ultrasound scan and avoiding manipulation of the ascending aorta [5]. It is the personal opinion of these authors that aortic cross- and side-clamping are allowed only in presence of normal ascending aorta, as assessed with epiaortic ultrasound whereas side-clamping may be allowed in presence of minimal atherosclerotic lesions located at the posterior wall of the aorta and thus quite far from the side-clamping site (Fig. 4). In case of more diffuse atherosclerotic lesions, any manipulation of the aorta should be avoided. This means that also forceful palpation of the aorta, usually and wrongfully used for assessment of the status of the ascending aorta, may result in dislodgment of atherosclerotic debris. As
Fig. 4. Flow chart of proposed treatment approach for preventing thromboembolism during isolated coronary artery bypass surgery. OPCAB: off-pump coronary artery bypass surgery; CCAB: conventional coronary artery bypass surgery; LIMA: left internal mammary artery; RIMA: right internal mammary artery. The square on the right bottom corner indicates the area of uncertainty whether the use of anastomotic devices is superior to no-touch aorta technique in preventing stroke.

an alternative technique, adequate myocardial revascularization along with avoidance of manipulation of the aorta can be successfully accomplished by using one or both internal mammary arteries and using T-graft configurations [23] (Fig. 4). However, some surgeons are reluctant to base total myocardial revascularization exclusively on the mammary arteries, and this may apply particularly to patients undergoing urgent/emergent CABG. In these cases, proximal anastomosis device could provide the surgeon with a rather fast and effective revascularization technique with minimal manipulation of the aorta. Among the proximal anastomosis devices, the Heartstring device is expected to allow proximal anastomoses, which are similar in terms of technical characteristics and likely durability to the conventional hand sewn anastomoses accomplished with aortic clamping. The goodness of the proximal anastomosis accomplished with the help of Heartstring device could not be confirmed in this study because of lack of data on graft patency. Furthermore, the risk of debris dislodgment is theoretically very low. In fact, Eldaif et al. [17] showed a significantly less amount of solid micro-emboli at transcranial monitoring with the use of the Heartstring device compared with partial aortic clamping in patients with normal aorta or aortic intimal thickening. These findings are in accordance with the results of a prospective study by Guerrieri Wolf et al. [18], which was anyway carried out without the aid of epi-aortic ultrasound. It remains the problem of a certain manipulation of the aortic intima by the seal of Heartstring, which could be of relevance in the presence of diffuse atherosclerosis lesions. Fig. 4 summarizes a diagnostic/treatment approach based on these concepts and indicates that patients identified at epi-aortic ultrasound having severely diseased ascending aorta are those who most likely benefit from avoidance of aortic manipulation or use of anastomotic devices. Thus, further research must be particularly focused on the latter patients.

The present meta-analysis showed that the pooled rate of postoperative stroke is not markedly reduced compared with other observation studies. However, the results of individual studies as well as of this meta-analysis may be flawed by the suboptimal study design of the former studies. The major and most frequent bias encountered is the lack of routine epi-aortic ultrasound to detected atherosclerotic changes in the ascending aorta and, in particular, at the site of anastomosis. Indeed, a rather low rate of stroke was observed among patients with diseased ascending aorta indicating its potential value in these patients. Furthermore, postoperative mortality and myocardial infarction rates were otherwise brilliant and suggest the safety and efficacy of using the Heartstring anastomotic device during CABG. We believe that a prospective, randomized study involving patients with severely diseased ascending aorta comparing the no-touch aorta technique and proximal anastomosis devices is hardly feasible because it would require a rather large number of patients. However, further prospective, observational studies including these high-risk patients may provide important insights regarding the neuroprotective efficacy of Heartstring as well as the patency of grafts anastomosed with this device.

In conclusion, the results of this study suggest that the risk of stroke after CABG may not be significantly reduced by the use of the Heartstring device. On the other hand, a rather low rate of stroke was observed among patients with diseased ascending aorta, indicating its potential value in these patients. Most studies included in this meta-analysis were of poor methodological quality, and properly conducted prospective studies are needed to get more conclusive results on
the safety and efficacy of the Heartstring anastomosis device.

References


