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Review

Effect of computed tomography before cardiac surgery on surgical strategy, mortality and stroke

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ABSTRACT

Aim: To investigate whether preoperative chest computed tomography (CT) decreases postoperative mortality and stroke rate in cardiac surgery by detection of calcifications and visualization of postoperative anatomy in redo cardiac surgery which can be used to optimize the surgical approach.
Methods: The PubMed, EMBASE and Cochrane databases were searched and articles concerning preoperative CT in cardiac surgery were included. Articles not reporting mortality, stroke rate or change in surgical approach were excluded. Studies concerning primary cardiac surgery as well as articles concerning redo cardiac surgery were both included.
Results: Eighteen studies were included ($n = 4057$ patients) in which 2584 patients received a preoperative CT. Seven articles ($n = 1754$ patients) concerned primary surgery and eleven articles ($n = 2303$ patients) concerned redo cardiac surgery. None of the studies was randomized but 8 studies provided a comparison to a control group. Stroke rate decreased with 77–96% (primary surgery) and 18–100% (redo surgery) in patients receiving a preoperative CT. Mortality decreased up to 66% in studies investigating primary surgery while the effect on mortality in redo surgery varied widely. Change in surgical approach based on CT-findings consisted of choosing a different cannulation site, opting for off-pump surgery and cancellation of surgery.
Conclusions: Current evidence suggests that preoperative CT imaging may lead to decreased stroke and mortality rate in patients undergoing primary cardiac surgery by optimizing surgical approach. In patients undergoing redo cardiac surgery stroke rate is also decreased but the effect on mortality is unclear. However, evidence is weak and included studies were of moderate quality.

1. Introduction

One of the most devastating complications of cardiac surgery is a postoperative stroke. The reported incidence of postoperative stroke after cardiac surgery varies between 1.4–9.7% and strongly depends on the surgical procedure [1–4]. The majority of postoperative strokes are embolic in nature and aortic calcifications are the most important risk factor [2,5]. The risk of a postoperative stroke is up to fourfold higher in patients with aortic atherosclerosis [2,6]. This is explained by the need to clamp and manipulate the ascending aorta during cardiac surgery, thereby releasing material from aortic plaques and calcifications that may embolize to the brain [7]. This is an important problem since approximately 14% of cardiac surgery patients have significant ascending aorta calcifications [8]. Furthermore, stroke is a significant health burden and associated with high costs. The average costs in the United States for the first year after a stroke are estimated to be $11,145 mainly due

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Table 1
Search syntax.

Search syntax	
Date of search: January 20th 2015	
Databases searched:	Search terms entered into databases:
PubMed	preoperat* OR
In title and Abstract	(pre AND operat*) OR
	prior OR
EMBASE	planning OR
In title and Abstract	before OR
	presurgical
Cochrane	
In title and abstract	AND
	CT OR
	(computed AND tomograph*)
	AND
	(cardiac AND (surgery OR operat*)) OR
	(cardiothora* AND (surgery OR operat*)) OR
	(heart AND (surgery OR operat*)) OR
	CABG OR
	(bypass AND (surgery OR operat*)) OR
	(valve AND replacement) OR
	(valve AND (surgery OR operat*))

to rehabilitation costs [9]. Preoperative knowledge of the presence and extent of aortic calcifications may be used to optimize or even adapt surgical strategy to avoid manipulation of the calcified aorta with the aim of preventing stroke. Redo cardiac surgery is associated with increased mortality and morbidity due to previously altered anatomic relationships [10]. Preoperative visualization of this altered anatomy can identify structures at risk of injury [11,12].

Standard preoperative work-up prior to cardiac surgery includes imaging by chest X-ray, angiography and/or echocardiography [13–15]. Aortic calcifications are often not accurately detected on a chest X-ray due to inherent limitations imposed by the 2D superposition of structures [16,17]. Intraoperative epiaortic ultrasound has been described as a valuable intraoperative tool to assess wall characteristics of the ascending aorta and determine the presence of aortic wall calcifications and soft plaque. However, major drawbacks are the restriction to intraoperative use, limited anatomical coverage and the requirement for additional operating time.

An alternative technique that can be used to precisely assess cardiac and aortic anatomy is computed tomography (CT) of the chest. This modality offers excellent preoperative visualization of the location and extent of aortic calcifications allowing improved preoperative planning with adaptation of cardiac surgical strategy in case of severe calcifications. Furthermore, a preoperative CT can identify the altered anatomy in redo cardiac surgery.

The objective of this study is to systematically review the available literature with regard to the effect of preoperative CT on optimizing surgical strategy, and subsequent stroke rate and mortality.

2. Materials and methods

PubMed, EMBASE and Cochrane electronic databases were searched for relevant articles on January 20, 2015. No time restrictions were applied. Synonyms of preoperative, CT and cardiac surgery were combined. The search syntax is provided in Table 1. Duplicates were removed and articles were screened by one person using predefined in- and exclusion criteria. Inclusion criteria were articles concerning preoperative CT for cardiac surgery and reporting surgical modification based on CT findings, postoperative mortality or stroke rate. Exclusion criteria were case and congress reports, non-English language, articles concerning pediatric populations and articles concerning transcatheter aortic valve implantation. The reference lists of included articles were screened for additional articles.

The quality of included studies was assessed by one person using a modified Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool [18]. Since the QUADAS tool is designed for quality assessment of studies concerning diagnostic accuracy, not all items were applicable. Non-applicable items were left out. Two items concerning study design were added (prospective versus retrospective design and single center versus multicenter study design). In addition, two items concerning outcome were added, namely whether a definition of the primary outcome stroke was provided and the time interval over which the secondary outcome mortality was measured namely in-hospital mortality or 30-day mortality (Table 2).

Data concerning author, title, publication date, journal, patient characteristics, CT acquisition, type of surgery, stroke rate and mortality were extracted to a standardized data sheet. Subgroup analysis was performed for studies investigating primary cardiac operation and studies investigating redo cardiac surgery.

We performed a systematic review of the published literature on the effect of preoperative CT on surgical strategy and postoperative mortality and stroke rate in patients undergoing primary and redo cardiac surgery. Preoperative CT can provide previously unrecognized information about aortic calcifications that has the potential to change surgical strategy, and, possibly, reduce the incidence of postoperative stroke and mortality.

3. Results

The search resulted in 4371 unique articles. A flowchart is provided in Fig. 1. Articles were excluded because they did not concern preoperative chest CT or did not report on the outcomes of surgical modification, mortality or stroke rate ($n = 4343$), non-English language ($n = 2$), concerned a case report ($n = 3$), was a congress report ($n = 1$) or concerned children ($n = 1$). A total of 19 articles were included. Two of the remaining articles [12,19] described the same study population. Only the most recent publication was included [12] therefore 18 unique articles were included.

Results of the critical appraisal are provided in Table 2. All studies clearly described their inclusion criteria. However, only four studies of the studies had a prospective study design and none of the studies was multicenter. Less than half of the studies (7 studies) described the CT acquisition in sufficient detail to permit its replication by not reporting if it was a contrast-enhanced CT and/or the used CT system and parameters. Four out of 13 studies investigating postoperative stroke provided a definition of stroke. All but one study investigating mortality defined if this was in-hospital or 30-day mortality.

None of the studies was randomized, leading to different patient populations. For the studies investigating primary cardiac operation, two studies with a control group only performed a CT-scan in high-risk patients with extensive atherosclerosis, history of cerebrovascular accident or transient ischemic attack, peripheral vascular disease or renal disease [20,21] while one study did not perform a CT-scan before emergency operations, if the CT-scanner was not available and in patients with renal failure or previous contrast reaction. For redo cardiac operation, in three retrospective studies a CT-scan was not performed routinely resulting in a control group of patients who did not receive a CT-scan [12,22,23]. One study only performed a CT-scan in high-risk patients with extensive atherosclerosis, history of stroke, peripheral vascular disease or renal disease [24] while emergency surgery, renal failure, previous contrast reaction or non-availability were reasons for not receiving a CT-scan in the remaining study [10].