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Hospital variability of postoperative sepsis and sepsis-related mortality after elective coronary artery bypass grafting surgery

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ABSTRACT

Purpose: Hospital variability of postoperative sepsis and sepsis-related mortality after elective CABG surgery was not known in Australia.
Material and methods: Population-based analysis of all elective patients who underwent CABG surgery in public and private hospitals between 2007 and 2014 using linked data from the state-wide Admitted Patient Data Collection and the NSW Registry of Births, Deaths, and Marriages.
Results: We identified 18,928 (9464 pairs) matched patients who had elective CABG surgery in public hospitals (n = 9) and private hospitals (n = 13) during the study period. When compared to public hospital patients, private hospital patients had a significantly lower rate of post-CABG sepsis (13.3 vs 20.4 per 1000 admissions, P < 0.001; treatment effects: −7.1, 95%CI: −11.1 to −3.3), a lower in-hospital mortality rate (6.1 vs 9.9 per 1000 admissions, P = 0.006; treatment effects: −3.8, 95%CI: −6.5 to −1.1), and a lower rate of 30-day readmission (11.9% vs 13.9%, P < 0.001; treatment effects: −2.0%, 95%CI: −3.1% to −1.0%). In addition, for both public and private hospital groups, there were significant differences for all outcomes when comparing the worst and best performance quintile hospitals.
Conclusions: Hospital variability of postoperative sepsis, in-hospital mortality and readmission after elective CABG existed between and within public and private hospitals.

1. Introduction

In Australia, >25,000 CABG procedures are performed each year, amounting to >100 per 100,000 general population [1] Given the use of a standardised surgical technique and well-established guidelines [2], it might be expected that variations in surgical complications, mortality and readmissions would be limited. However, outcomes and complications have been reported to vary widely across hospitals [3,4]. In addition, perioperative complications, including sepsis, have been identified as significant risk factors for death and early readmission [3,5]. These observations from the USA suggest that there is the potential to improve the care and outcomes of these patients by understanding the extent and nature of such variation in Australia, especially in the area of postoperative sepsis.

Postoperative sepsis is a major, and potentially preventable, complication of cardiac surgery. The variability in post CABG or cardiac surgery-associated sepsis related mortality reached a three-fold difference between the worst and best quintile hospitals [6]. In Australia, similar variation was seen among all cardiac surgery patients [7]. For isolated CABGs, another Australian study found a 5.6%–9.9% complication rate, and a 5.4%–23.1% complication-related mortality rate between the best and worst quintile hospitals, but focused only on patients admitted to public hospitals [8]. The findings from these two Australian studies were based on pooled elective, urgent and emergency operations [7] or elective operations only in public hospitals [8], and the outcomes of patients operated in private hospitals was not assessed.

To understand the full extent and impact of variation in outcomes and complications across the whole health care sector, we aimed to explore the outcomes, and variation in outcomes, in relation to sepsis, sepsis-related mortality and sepsis-related complications for all elective CABG surgery for both public and private hospitals in the state of New South Wales (NSW), Australia.

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2. Methods

2.1. Data source and study population

We conducted a population-based retrospective cohort study using the NSW administrative data from the Admitted Patient Data Collection (APDC). Briefly, the APDC includes information on patient demographics, medical conditions and procedures, hospital characteristics, and separations (discharges, transfers and deaths) from all public and private hospitals in NSW [9]. The medical records for each episode of care in the APDC were assigned codes based on the International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) [9].

The data we obtained included all adult elective surgical patients admitted to NSW hospitals between 1st January 2007 and 31st March 2014. We identified our study population based on the selection criteria developed by the US Agency for Healthcare Research and Quality (AHRQ) for the defined "postoperative sepsis" [10]. In this regard, "postoperative sepsis" is one of the key patient safety indicators (PSIs) developed by the AHRQ aiming to monitor potentially preventable surgical complications among elective surgical patients without serious medical conditions at admission. The AHRQ safety indicators were proposed after a comprehensive literature review, analysis of ICD-9-CM codes, review by a clinician panel, implementation of risk adjustment, and empirical analyses, and have been widely used in the United States to measure aspects of patient safety and quality and to monitor the impact of quality improvement initiatives [11,12].

Consistent with the AHRQ selection criteria, we included all elective surgical patients (aged ≥18 years) who had principal procedure codes for isolated CABG operations (Supplementary material: Appendix 1) and not admitted through the emergency department. We excluded those patients who fulfilled any one of the following exclusion criteria:

- CABG performed with other cardiac surgical procedures (e.g. cardiac valve surgery)
- a principal diagnosis on admission that was sepsis or infection (Supplementary material: Appendix 2); or
- any ICD-10-AM diagnosis codes for cancer; or
- any ICD-10-AM diagnosis codes or any ICD-10-AM procedure codes for immunocompromised state; or
- Major Diagnostic Categories (MDC) 14 (pregnancy, childbirth, and puerperium); or hospital stay of <4 days.

We also excluded those patients who had repeated CABG surgery and those who had a principal non-CABG procedure in an operating room up to 30 days before the CABG surgery.

Among the selected study population, postoperative sepsis cases were identified by ICD-10-AM diagnosis codes (Supplementary material: Appendix 2). Because the coding system in the U.S. (ICD-9-CM) is different from that in Australia (ICD-10-AM), all diagnoses and procedure codes in the AHRQ definition were translated to ICD-10-AM codes according to the Organisation for Economic Co-operation and Development (OECD) technical manual for patient safety indicators [9,13]. We created outcome variables of postoperative sepsis using 54 non-principal diagnostic fields in the medical record by ICD-10-AM codes matched from the OECD manual [9]. We also identified those admitted with sepsis within 7 days of their CABG surgery as postoperative sepsis cases. The selected data were linked to the NSW Registry of Births, Deaths, and Marriages through the Centre of Health Record Linkage, NSW Ministry of Health to derive 30-day post-discharge mortality [9]. We then classified the study population into public and private hospital cohorts and performed nearest neighbour matching in order to compare patient outcomes between types of hospitals (Fig. 1).

2.2. Patient demographic, hospital characteristics and clinical information

Patient demographic information included age, gender, country of birth, severity of comorbidity, marital status, advantaged and disadvantaged Socio-Economic Indices For Areas (SEIFA) scores [14] (categorised into four classes: 1st quartile = most disadvantaged areas and 4th quartile = most advantaged areas) representing patient socio-economic position and hospital locations s (metropolitan or rural/regional NSW). Severity of comorbidity was defined by the Charlson Comorbidity Index score based on the ICD-10 coding scheme [15]. We classified the severity of comorbidity into four categories: normal (index score = 0), moderate (index score = 1), severe (index score = 2), and very severe (index score ≥ 3) [9]. Because the AHRQ selection criteria excluded patients with any cancer or immunocompromised state, three of the Charlson comorbidities such as any malignancy (including leukaemia and lymphoma), metastatic solid tumour and AIDS/HIV were excluded. Thus, the comorbidities in this study only encompassed 14 of the Charlson defined comorbidities, including: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, peptic ulcer disease, mild liver disease, diabetes without chronic complications, diabetes with chronic complications, hemiplegia or paraplegia, renal disease and moderate or severe liver disease [9]. Clinical information included length of stay, blood transfusion status (yes/no, identified using ICD-10-AM procedure codes "13706-02" and "13706-05"), and procedure type (on-pump or cardiopulmonary bypass/off-pump or non-cardiopulmonary bypass). We identified on-pump CABG as a CABG procedure with any secondary procedure coded as "38600-00" or "38603-00". Otherwise, it would be classified as off-pump CABG procedures.

2.3. Study outcomes

The primary outcomes measured the occurrences of post-CABG sepsis and sepsis related deaths during hospitalisation, including (i) incidence rate of postoperative sepsis: the number of sepsis cases divided by total number of the study population; (ii) sepsis case fatality rate: the number of deaths among sepsis cases divided by the number of sepsis cases; (iii) incidence rate of sepsis related deaths: the number of deaths among sepsis cases divided by the total number of the study population.

The secondary outcomes were overall mortality (in-hospital and 30-day post-discharge) and 30-day readmission to a hospital (for any reason) among elective CABG patients. The secondary outcomes were calculated as (i) in-hospital mortality rate: the total number of in-hospital deaths divided by the total number of the study population; (ii) 30-day post-discharge mortality: the number of deaths within 30 days after discharge divided by the total number of individuals who survived to discharge; (iii) 30-day readmission rate: the number of cases readmitted to a hospital within 30 days (excluding those who transferred to other hospitals at the discharge or those who readmitted as the same day clinic visits) divided by the total number of individuals who survived to discharge.

2.4. Statistical analysis

Baseline characteristics were compared between the public and private cohorts by unpaired *t*-test and the Rao-Scott Chi-square. We compared the primary and secondary outcomes firstly between public and private hospitals, and secondly within each group by rank. To obtain the balanced samples of the CABG patients in public and private hospitals, we conducted the nearest neighbour matching method based on Euclidean matrix [16] to examine hospital variations in the incidence of postoperative sepsis, sepsis related mortality, in-hospital mortality, 30-day post-discharge mortality and 30-day readmission between public and private hospitals. We performed a sensitivity analysis for each