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The Impact of COVID-19 on the Provision of Adult Cardiac Surgery at a Dedicated COVID Hospital in Australia

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Background
Internationally, the response to the COVID-19 pandemic has resulted in fewer cardiac surgical procedures being performed and an increase in the proportion of non-elective cases. To date there has been no study examining the impact of COVID-19 on the provision of cardiac surgery in Australia.

Aim
The aim of this study was to evaluate the impact that the COVID-19 pandemic has had on the provision of cardiac surgery in a single, large major cardiac centre and dedicated COVID-19 hospital. A retrospective cohort study was undertaken utilising prospectively collected data.

Methods
Prospectively collected patient and operative data was examined to assess whether there was a reduction in the number of cases performed and whether there was a difference in patient demographics, surgical procedures or case urgency. Data was examined from the period of COVID-restrictions in 2020 and compared with data from the same time period in 2019.

Results
From 3 March 2020 to 30 June 2020, 136 adults underwent cardiac surgery at our institution, representing an overall reduction in operative caseload of 21%. The largest impact was noticed in May and April and coincided with statewide restrictions on elective surgery. Surgical acuity was unchanged with 58% of operations classified as non-elective procedures performed during the index admission. There was a small non-significant increase in the proportion of isolated coronary artery bypass surgery and aortic valve surgeries performed.

Conclusion
From March to June 2020 our local hospital response to the COVID-19 pandemic resulted in a reduction in cardiac surgery service delivery. No change was seen in the urgency or type of surgeries performed.

Keywords
COVID • Cardiac surgery • Cardiothoracic • CABG

Introduction
Coronavirus disease 2019 (COVID-19) is the disease caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]. First reported in Wuhan City, China, in December 2019 the virus quickly spread worldwide resulting in the World Health Organization declaring a global pandemic on 11 March 2020. Internationally, COVID-19 has significantly impacted the provision of cardiac surgery due to the resource intensive nature of the service and the requirement for admission to intensive care postoperatively. In Lombardy, Italy, 16 of 20 cardiac centres were closed and

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only the most urgent cases proceeded [2]. In Greece, Lazaros et al. reported a 67% reduction in case volume (from 246 to 84) and a doubling in the proportion of urgent procedures (from 15.5% to 32.1%) during the period of reduced operating in 2020 compared to the same period of time in 2019 [3]. Casey et al. reported similar findings from Ireland with a 49% reduction in operations performed and an increase in urgent operations from 40% to 61% [4].

Our institution is a major teaching hospital and nominated COVID-19 centre and has one of the largest cardiac surgery units in Australia. Extensive organisational changes have been required to reduce the risk of virus transmission and increase the capacity to care for patients with COVID-19. In preparation for an expected rise in cases our institution reduced all non-essential surgical services with immediate effect from 9 March 2020 and redeployed surgical staff to COVID clinics. In addition, the perioperative unit was converted into an intensive care unit, taking the number of intensive care unit (ICU) beds from 54 to 73 and increasing the capacity for ventilated patients to 57. On 25 March 2020, NSW Health mandated the suspension of all non-urgent elective surgery to ensure public hospitals had adequate capacity to respond to COVID-19. This mandate was subsequently lifted on 1 July 2020. To date, there has been no study examining the impact that COVID-19 has had on the provision of cardiac surgery within Australia. The objective of this paper was to assess the impact that the COVID-19 pandemic has had on the provision of cardiac surgery at our institution.

Methods

Study Design

This is a retrospective cohort study with historical control using prospectively collected data to examine the impact of COVID-19 on the provision of cardiac surgery. This study was undertaken in line with the Strengthening The Reporting of Observational studies in Epidemiology (STROBE) guidelines and was approved by the institutional ethics review board (X20-0480).

Study Population and Data Collection

The department of cardiothoracic surgery maintains a prospectively collected database of all patients who undergo major cardiac surgery, from which data was obtained for this retrospective analysis. Inclusion criteria included any adult cardiac surgery performed in the operating theatre. Primary extracorporeal membrane oxygenation cases without cardiac surgery and transcatheter aortic and mitral valve procedures were excluded. Data for analysis was obtained for the period 9 March 2020 until 30 June 2020, and from the same time period in 2019 for comparison as an historical control. The number and type of operations performed, as well as demographic data were reviewed. The relative reduction in 2020 was expressed as a percentage of the 2019 caseload.

Results

Patient and Operation Characteristics

Total number of operations, patient characteristics and operation characteristics are presented in Table 1. Cases initially curtailed in early March 2020 following the institution of local restrictions on operating capacity and more heavily following the statewide restriction on elective operating. From 9 March until 31 June 2020 the number of major adult cardiac surgery procedures performed at Royal Prince Alfred Hospital was 136, compared to 172 during the same period in 2019, a reduction of 21%. The most noticeable reduction was observed in the months of April and May (30% and 23%, respectively) (Figure 1). No differences were observed between the two groups in regard to baseline patient characteristics age, gender, Indigenous status, and mean preoperative characteristics. Cases initially assessed using the Chi square or Fisher’s exact test. Significance was set at a p-value of 0.05 and all statistical analyses were performed using SPSS Statistics v26 (IBM Corp., Armonk, NY, USA).

Procedures Performed

The types of procedures performed are summarised in Figure 3. There were 78 isolated coronary artery bypass graft (CABG) surgeries performed in the 2020 COVID period and this represented 57% of all major cardiac operations. This is compared with 92 (54%) isolated CABG procedures performed during the equivalent period in 2019. Aortic valve surgery, including repair and replacement but excluding aortic root and combined procedures, was performed 17 times (13%) in 2020 compared with 15 (9%) in 2019. There was a total of 7 (5%) isolated mitral valve procedures performed in 2020, compared with 11 (6%) operations.
Other operations include those performed for aortic aneurysm and dissection, procedures performed on the aortic root, excision of cardiac masses, and combined procedures. There were 34 (25%) such procedures performed in 2020 compared with 54 (31.4%) in 2019. The difference in observed numbers of each procedure type was non-significant (p=0.64).

Hospital Length of Stay

For analysis we divided hospital length of stay into preoperative length of stay and postoperative length of stay. Distribution of values for pre and postoperative length of stay were positively skewed. Median preoperative length of stay was 5 days (0–10 days) in 2019 and 3 days (0–8 days) in 2020. Median postoperative length of stay.
stay was 8 days (6–13 days) in 2019 and 9 days (7–12 days) in 2020, statistically non-significant results. Subgroup analysis examining isolated non-elective CABG showed no significant difference in time from angiography to surgery (8 days [6–18] during the COVID period versus 7 days [4–14], p=0.25).

**Discussion**

An exploratory single unit level analysis was conducted to examine the impact of COVID-19 on the provision of cardiac surgery in a large Australian tertiary public hospital and nominated COVID centre. The observed reduction in operating capacity was consistent with international experience [2–5]. Despite a reduction in operating capacity of over 20% during the COVID-19 period our institution did not observe a significant change in the demographic of patients undergoing surgery, the urgency of procedures performed, or the types of procedures performed. Sensitivity analysis looking at the 2 months most affected by COVID restrictions, April and May, did not reveal any significant differences in patient demographics or outcomes between 2019 and 2020. We had
anticipated fewer elective procedures due to the restrictions
instituted by NSW Health but instead found that the pro-
portion of elective operations did not change. One reason for
this could be due to our institution having a relatively long
wait list and a proportion of those patients were of sufficient
clinical urgency that we were permitted to schedule their
cases during the COVID-19 period. Another reason that no
significant change was detected could be the fact that our
institution performs a greater proportion of urgent cases than
the national average for our specialty. The most recent data
published by the Australian and New Zealand Society of
Cardiac and Thoracic Surgeons (ANZSCTS) reported that the
proportion of CABG procedures, isolated valve surgeries,
and combined CABG and valve procedures that were
undertaken electively in 2018 were 60%, 84% and 77%,
respectively [6]. Based on these numbers it is evident that the
proportion of patients undergoing urgent procedures at our
institution (53%) was higher than expected prior to the
COVID-19 pandemic.

Comparing the type of cases performed we observed a
slight increase in the proportion of CABG and aortic valve
surgery performed during the COVID period in 2020,
although this result did not reach significance. This may
represent a true variation in case distribution as a result of
the postponement of elective operations in the ‘other’ cate-
gory but failed to reach significance due to small sample size.
Looking specifically at each of these procedures there was no
significant difference in urgency, patient demographics, risk
profile or hospital length of stay.

Elsewhere in the country COVID-19 has had a more visible
impact. Drysdale and colleagues [7] investigated the impact
of COVID-19 on the clinical activity of their general surgical
unit in Geelong. They reported a 46% reduction in elective
operations compared with the same time period in 2019,
including a 30% reduction in category 1 cases. This capacity
for elective procedures was only able to be maintained by
performing public cases in the private sector, a practice
which increased in volume by 800%. They also reported a
30% decline in overall emergency presentations, resulting in
a 6% decline in emergency general surgical admissions,
although interestingly the number of emergency general
surgical operations increased by 14%. This trend may reflect
the community’s fear of presenting to the emergency
department during the COVID-19 pandemic, resulting in
only the very unwell presenting for review.

Salenger et al. [5] used modelling to estimate the backlog
of patients awaiting cardiac surgery and therefore the time
and additional resources required to service this backlog.
Whilst such calculations rely upon making several assump-
tions it demonstrates the prolonged impact this pandemic is
going to have on the ability to deliver surgical care. This
increase in patients awaiting surgery did not result in longer
inpatient wait times or longer time from angiography to
surgery. This observation is most likely due to a commen-
surate reduction in coronary angiograms as our institution
suspended elective angiograms during the COVID period
but might also be due to patients’ reluctance to present to
hospital during the pandemic.

Conclusion
Aside from the expected reduction in operative numbers it
was surprising to find that COVID-19 has thus far had no
impact on the types of procedures performed or the pro-
portion of elective cases undertaken at our institution.
However, the lack of a statistical difference between groups
in regard to these variables may be due to the small sample
size in our study. The Australian & New Zealand Society of
Cardiac & Thoracic Surgeons (ANZSCTS) maintains a data-
base of all adult cardiac surgical procedures performed in
participating units. Currently, 23 out of 24 public hospital
units and 17 private hospital units are members of the pro-
gram. Utilising this database could overcome this limitation
and allow for more robust statistical analysis to be
performed.

Conflicts of Interest
This research did not receive any specific grant from funding
agencies in the public, commercial, or not-for-profit sectors.

References
[1] World Health Organization. Coronavirus disease 2019 (COVID-19): situ-
tation report, 94. World Health Organization. 2020. Available at: https://
apps.who.int/iris/handle/10665/331865, [accessed 25.11.20].
[2] Bonalumi G, di Mauro M, Garatti A, Barilli F, Gerosa G, Parolari A. Italian
Society for Cardiac Surgery Task Force on COVID-19 Pandemic. The
COVID-19 outbreak and its impact on hospitals in Italy: the model of
cardiac surgery. Eur J Cardiothorac Surg. 2020;57(6):1025–8.
[3] Lazaros G, Oikonomou E, Theodilis P, Theodoropoulou A, Trantafyllou K,
Charitos C, et al. The impact of COVID-19 pandemic on adult cardiac
surgery procedures. Hellenic J Cardiol. 2020;62(3):231–3.
[4] Casey L, Khan N, Healy DG. The impact of the COVID-19 pandemic on cardiac
surgery and transplant services in Ireland’s National Centre. Ir J Med Sci.
2021;190(1):13–7.
[5] Salenger R, Echill EW, Ad N, Matthew T, Alejo D, Whitman G, et al. The
surge after the surge: cardiac surgery post-COVID-19. Ann Thorac Surg.
2020;100(6):2020–5.
[6] Gilbert S, Jenni W-S, Tran L, Noah S, Jenna M, Nicole M, et al., on
behalf of the ANZSCTS Database. The Australian and New Zealand
Society of Cardiac and Thoracic Surgeons Cardiac Surgery Database
Program National Annual Report 2018. Melbourne, Australia: Mon-
ash University, DEPM; 2019. Report No 12.
[7] Drysdale HRE, Ooi S, Geelong Surgical COVID-19 Response Team,
Nagra S, Watters DA, Guest GD. Clinical activity and outcomes
during Geelong’s general surgery response to the coronavirus
disease 2019 pandemic. ANZ J Surg. 2020 Sep;90(9):1573–9.