

The Effects of the COVID-19 Pandemic on Cardiac Surgery Volumes and Outcomes in New Zealand

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INTRODUCTION

New Zealand's experience with the COVID-19 pandemic has been different from most of the world, with lower community and hospital case numbers and a shorter lockdown period. Additionally, as New Zealand is a geographically remote island nation with a low population density, an approach aiming for the complete elimination of the virus was implemented. On February 28, 2020, the first coronavirus case was confirmed in New Zealand. This progressed to a full "alert level 4" lockdown by March 25 [History of the COVID-19 Alert System 2021].

Cardiac surgery is a unique specialty in that its patient population is inherently high risk and routinely requires postoperative intensive care unit (ICU) admission. This created an obvious strain during the COVID-19 pandemic, with health systems redistributing resources to best deal with the surge of high acuity and resource-intensive coronavirus infected patients, who often require intensive care admission and invasive ventilation [Nguyen 2021].

Since the World Health Organization declared a global pandemic in March 2020, a balance between maintaining elective surgical services and rationing ICU resources for patients with COVID-related respiratory failure has been a priority for hospitals [World Health Organization 2021]. New Zealand has an unusually low ICU capacity relative to other developed countries in our region. New Zealand has four ICU bed spaces per 100,000 population. Comparatively, Australia has more than double that figure with 9.4, placing New Zealand with one of the lowest ICU capacities in the OECD [Ministry of Health NZ 2021]. This low ICU bed capacity had a significant influence on the NZ decision to close its borders early, adopt an early lockdown, and peruse an elimination strategy to keep community transmission, and hospital and ICU admissions as low as possible [Young 2021].

Coronavirus infection in postoperative cardio-surgical patients is particularly high risk due to the multiple comorbidities associated with cardiovascular disease (e.g., heart failure, respiratory disease, diabetes mellitus, smoking,

etc.). Also, the use of cardiopulmonary bypass (CPB) exposes blood to non-endothelial surfaces, leading to an up-regulation of inflammatory cytokines and a compounding effect of the coronavirus infection [Lawday 2021]. An international cohort study of 235 hospitals in 24 countries revealed 30-day mortality across all surgical specialties of 23.8% for patients, who developed COVID in the perioperative period. Patients undergoing cardiac surgery had an even higher 30-day mortality of 34%, with 94% of cardiac surgical patients with COVID experiencing pulmonary complications – described as pneumonia, acute respiratory distress syndrome, or unexpected postoperative ventilation (non-invasive ventilation/re-intubation) [Lawday 2021].

Given these risks, many surgical societies recommended that hospitals postpone as many deferrable elective cardiac surgeries as possible. However, these patients have been shown to have a mortality risk associated with prolonged time on waiting lists [Khanna 2020; Jackson 1999], and this risk of deferment must be balanced against the risk posed with developing COVID infection in the perioperative period for each individual patient [Salenger 2020].

The international cardiac surgical activity showed a worrying decline in volumes during the COVID-19 pandemic. A study conducted across 67 cardiac surgery institutions in the United States saw an overall reduction of 53% of cardiac operations, during the months of March-April 2020 [Nguyen 2021]. These findings have been replicated in Ireland when comparing the months of March-April 2019 to 2020. Operative activity fell by 51% in 2020, with a significantly higher proportion of acute cases being performed (61% in 2020 vs. 40% in 2019.) Valvular surgery was 89% of the previously observed volume, whereas coronary artery bypass surgery saw a more dramatic decline at 61% of total volume compared with the previous year [Casey 2020].

Given New Zealand's comparatively low rates of community COVID cases and hospital and ICU admissions [History of the COVID-19 Alert System 2021], this study aims to compare our cardiac surgical activity and outcomes during the first wave of the 2020 COVID-19 pandemic to that seen around the world.

METHOD

Wellington hospital is a 484-bed tertiary hospital located in the lower North Island of New Zealand, providing tertiary cardiac surgical services to a regional population of

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1.3 million people and performing approximately 650 adult cardiac surgical procedures per annum. All publicly funded cardiac surgery is prospectively collected in the New Zealand National Cardiac Surgery Registry (NZCSR) using Dendrite Systems Software. The NZCSR collects pre-, intra-, and postoperative patient data using ANZSCTS data definitions [Ministry of Health NZ 2021]. Data is collected as part of a national registry and individual patient consent is not required. Analysis of the data in this paper was undertaken following institutional review and approval of the project.

Using our local data submitted to NZCSR, we identified all adult patients (>18 years) who underwent a cardiac operation in the Wellington region, from January 1, 2019, to December 31, 2019, and January 1, 2020, to December 31, 2020. Exclusion criteria included anyone under the age of 18 and any cardiac operations that were privately funded. Data regarding COVID-19 cases and alert levels were gathered directly from the New Zealand Ministry of Health website [Young 2021].

Given that the alert level 4 lockdown period in New Zealand began in late March 2020 and stepped down to level 3 in late April, the 2-month period of March and April is considered the lockdown period [Young 2021]. This period was compared with the following months of May through December of each year as the post-lockdown period to analyze for any ‘rebound effects’ of the lockdown.

Patients from each group were examined to identify if there were any unique baseline demographic differences between cohorts of patients undergoing operations during the lockdown period, compared with before and after. Baseline demographic analysis included mean age, gender, smoking status, diagnoses of diabetes, renal failure requiring dialysis, and left ventricular ejection fraction.

All cardiac operations were included to examine overall surgical volume trends, with additional stratification into elective and acute procedures. Acute procedures were defined as any operation required during the same hospitalization as their initial admission. The primary goal was to assess adult cardiac surgery volume trends before, during, and after the initial COVID-19 lockdown in New Zealand. Secondary goals included assessing a change in the percentage of elective procedures and the breakdown of surgery type.

Using “Python Programming” and “SciPy. Stats”, a two-sided t-test was used to assess the significance of variation in cardiac surgery volume (both acute and elective) during and after the lockdown period. Following this, a Fisher-Exact test was completed to assess the correlation between each year (2019 and 2020) and the proportion of acute and elective surgeries.

RESULTS

Baseline demographics were similar across all groups. (Table 1) Over the time periods of January 1, 2019, through December 31, 2019, and January 1, 2020, through December 31, 2020, a total of 971 cardiac operations were completed in the Wellington region. The majority of these were completed

in the 2020 time period, with 520 cardiac operations, compared with 451 in 2019. No cardiac surgical patients tested positive for COVID during the study period, and there were no positive COVID patients admitted to the cardiac surgical ward. Over the study’s period, only one patient was admitted with COVID for ventilation to our ICU and managed in a segregated negative pressure area of the ICU.

The data were analyzed in two groups: the lockdown period from March-April 2020, and the post-lockdown period from May to December 2020. These were compared against the corresponding periods in 2019. The lockdown period of March-April 2020 showed a higher but not statistically significant number of cases per month when compared with the corresponding 2019 period (48.5 vs. 39.0 cases per month, $P = 0.74$). Of note, this also was comparable with the post-lockdown period of May-December 2020 or May-December 2019 (43.8 cases per month vs. 38.1 cases per month, $P = 0.62$).

There was an increase in both elective and acute cardiac operations completed in 2020, with a greater increase being seen in acute cardiac operations, as demonstrated by Boxplots 1 and 2. (Boxplot 1) (Boxplot 2) This led to an overall decrease in the proportion of elective surgeries in the lockdown period when compared with 2019 (93.2% in March-April 2019 vs. 84.5% March-April 2020), despite an increase in the absolute number of elective surgeries completed during this time period. There was a threefold increase in acute cases completed per month, during the lockdown period of March-April 2020, then in the same time period in 2019 (7.5 vs. 2.5, $P = 0.09$). There also was a similar volume of acute cardiac surgeries completed per month in the post-lockdown period in 2020, when compared with its 2019 counterpart (6.3 vs. 9.8, $P = 0.14$). Of note, there is an increase in acute cardiac operations in late 2020 from the months of September through December, when compared with the same time period in 2019 (September-December 2019 vs. September-December 2020).

A Fisher-Exact test was completed to assess whether there was a difference in a split between acute and elective surgeries in 2019 or 2020. This showed that the difference in a split of the lockdown period tended toward, but is not statistically significant, with a P-value of 0.09, as did the post-lockdown period with a P-value of 0.06.

Analysis of the breakdown of operations by surgery type demonstrates a larger proportion of isolated CABG and single valve operations in the March-April 2020 period, when compared with 2019. There also are fewer aortic procedures completed with only three in the lockdown period in 2020, contrasted with 10 in March-April 2019. Of note, all three of these operations were acute operations for patients presenting with Type-A aortic dissections.

DISCUSSION

Many countries across the world have felt the impact of the COVID-19 pandemic, and health systems have been challenged to address the influx of infected patients

Table 1. Table showing demographics of patients across different selected time periods

Variable	January-February 2019	January-February 2020	March-April 2019	March-April 2020	May-December 2019	May-December 2020
N	68	74	78	97	305	350
Age (mean)	63.3	64.5	61.2	64.4	65.9	63.0
Male (%)	49 (72%)	51 (69%)	63 (81%)	72 (74%)	194 (64%)	261 (75%)
Smoking history	37 (54%)	25 (34%)	31 (40%)	52 (54%)	111 (37%)	163 (47%)
Diabetes mellitus (%)	15 (22%)	16 (22%)	16 (21%)	17 (17%)	67 (22%)	66 (19%)
Left ventricular ejection fraction						
Normal (>55%)	47 (69%)	47 (64%)	55 (71%)	63 (65%)	193 (63%)	219 (63%)
Borderline low (50-54%)	10 (15%)	7 (9%)	1 (1%)	14 (14%)	29 (10%)	37 (11%)
Impaired function (36-49%)	7 (10%)	12 (16%)	1 (1%)	15 (15%)	52 (17%)	42 (12%)
Severely impaired (<35%)	1 (1%)	3 (4%)	3 (4%)	0 (0%)	10 (3%)	11 (3%)

Table 2. Total cardiac surgery operations are split by month

Month	2019	2020	Grand total
January	33	37	70
February	35	37	72
March	39	52	91
April	39	45	84
May	46	53	99
June	37	48	85
July	38	56	94
August	47	50	97
September	45	38	83
October	33	36	69
November	28	40	68
December	31	28	59
Grand total	451	520	971

Table 3. Table of total surgeries split by time period

Time Period	No. of cases
January-February 2019	68
January-February 2020	74
March-April 2019	78
March-April 2020	97
May-December 2019	305
May-December 2020	350

Table 4. Table of cases/per month split by time period

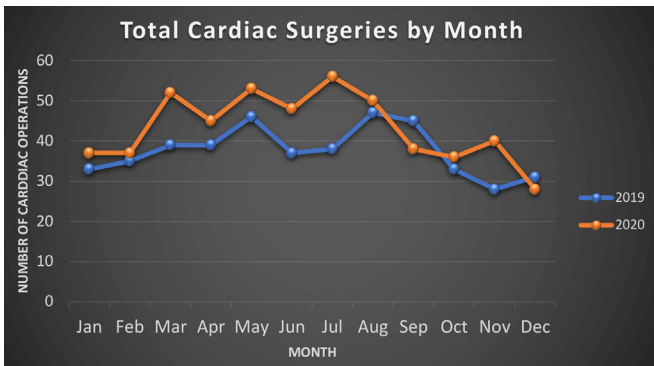
Time period	Cases/month
January-February 2019	34.0
January-February 2020	37.0
March-April 2019	39.0
March-April 2020	48.5
May-December 2019	38.1
May-December 2020	43.8

Table 5. Acute cardiac surgery operations split by month

Acute cardiac surgeries per month	2019	2020	Grand total
January	2	6	8
February	3	7	10
March	2	9	11
April	3	6	9
May	5	7	12
June	7	8	15
July	9	3	12
August	6	3	9
September	5	10	15
October	2	19	21
November	5	15	20
December	11	13	24
Grand total	60	106	166

Table 6. Elective cardiac surgery operations are split by month

Elective cardiac surgeries per month	2019	2020	Grand total
January	31	31	62
February	32	30	62
March	37	43	80
April	36	39	75
May	41	46	87
June	30	40	70
July	29	53	82
August	41	47	88
September	40	28	68
October	31	17	48
November	23	25	48
December	20	15	35
Grand total	391	414	805



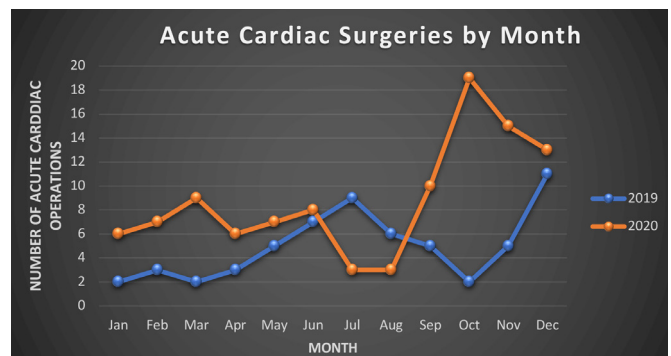
Graph 1. Total adult cardiac operations split by month

while trying to maintain equity of health care for all. Cardiac surgery is not unique in being impacted by the pandemic with all specialties needing to rationalize care and redistribute resources and personnel during this time. Many other international studies have assessed adult cardiac surgery volumes during the height of the coronavirus pandemic period. That experience has been of reductions in cardiac operating volume with increases in mortality during further increases in morbidity and mortality predicted in the future due to deferment of operations [Nguyen 2021; Khanna 2020; Salenger 2020; Casey 2020; Keizman 2020]. This is the first report of cardiac surgical volumes during the COVID-19 pandemic in New Zealand. This is important, as New Zealand has had a privileged and distinctive experience with the COVID-19 pandemic, with shorter lockdown periods, fewer case numbers, and complete eradication of the coronavirus from the country for months at a time [History of the COVID-19 Alert System 2021; Young 2021].

This study examines all cardiac surgery operations for people living within the lower half of the North Island to the

Table 7. Cardiac surgery operations split by surgery type during the lockdown period

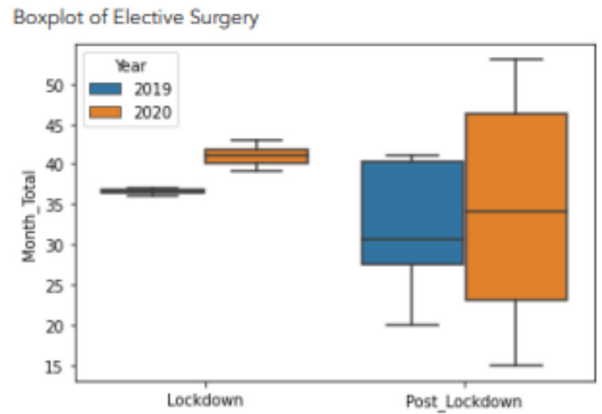
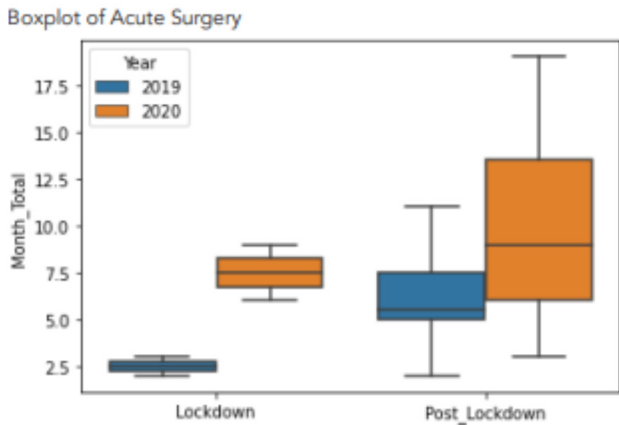
Surgery type	March-April 2019	March-April 2020
CABG	39	42
AVR	10	18
MVR	5	17
MVR + TVR	2	6
AVR + MVR	1	1
AVR + MVR + TVR	0	1
AVR + CABG	9	5
MVR + CABG	1	2
Aortic procedure	9	3
Other	2	2
Total	78	97



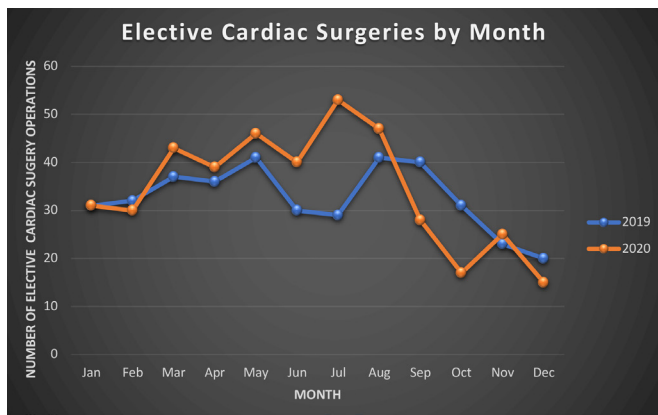
Graph 2. Acute cardiac surgery operations split by month

northernmost region of the South Island. Although definitive conclusions cannot be made for the whole of New Zealand, this study does capture a large proportion of all cardiac operations in New Zealand.

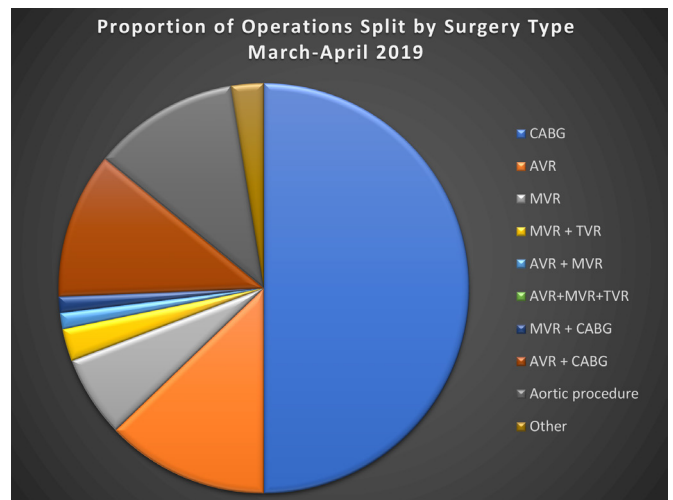
The increase in operating numbers during the lockdown period of March-April 2020, although not statistically significant when compared with the corresponding period in 2019, argues against any drop in COVID-related adult cardiac operating capacity. A small decrease in the proportion of elective operations in the 2020 time period, most notably in the lockdown period of March-April 2020 when compared with March-April 2019, is attributed to a greater increase of acute cases rather than a drop in elective operations, as demonstrated by the overall increase in total operations. One notable spike in acute cardiac surgery is noted in late 2020, from the months of September-December. This likely can be attributed to the lockdown period, during which time the majority of cardiology outpatient clinics and diagnostic services such as angiography, echocardiography, and radiological scans largely were postponed, and many higher acuity elective patients transitioned to acute in-hospital care and diagnostics.



Boxplots 1 and 2. Spread of acute and elective cardiac surgeries per month in both the lockdown and post-lockdown periods



Graph 3. Elective cardiac surgery operations split by month



Graph 4. Pie graph showing distribution of adult cardiac surgery split by surgery type for March-April 2019. CABG, coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement; TVR, tricuspid valve replacement

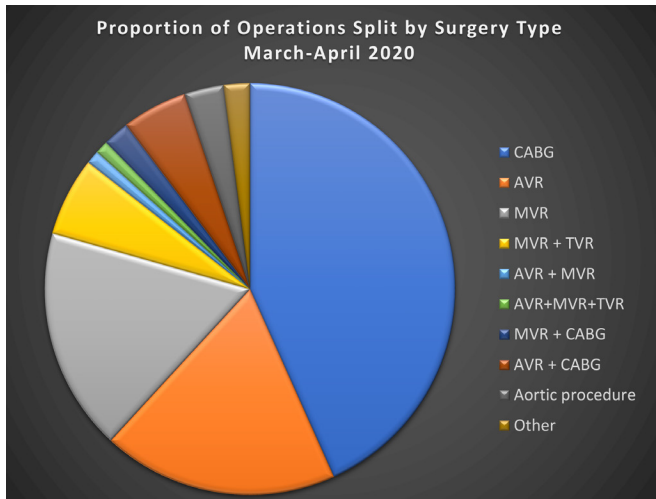
One definitive change that can be attributed to the lockdown period is the decrease in aortic procedures. Only three were completed in March-April 2020 when compared with nine in the same time period a year prior. All three of these operations were acute Type-A dissections, suggesting all elective aortic operations were postponed for this time. This is likely due to the more complex nature of these operations and the possibility of longer intensive care unit admission with a higher risk of postoperative complications. There also was a larger proportion of isolated single valve and isolated coronary artery surgery in March-April 2020, when compared with 2019, suggesting a preference for more succinct operations with shorter hospital lengths of stay. As far as our research identified, there were no patients diagnosed with coronavirus infection during the perioperative period.

Several limitations have been identified from our study, including the focus on operations completed in the Wellington region only. This contributed to fewer overall cases being observed and reduced the power of the study. It also limits our ability to extrapolate the data to make conclusions for the whole of New Zealand, as different regions experienced different burdens during the COVID-19 pandemic. It also focuses on the initial breakout of COVID-19 in New Zealand,

and there since have been further outbreaks each with its own national or regional lockdowns.

CONCLUSION

The COVID-19 pandemic has had a detrimental effect globally on health systems, with acutely unwell patients being prioritized over those scheduled for elective operations. Our data suggest no reduction of adult cardiac surgery case volume in the Wellington region during the lockdown period in March-April 2020. Case volumes remained steady and a non-statistically significant increase in both acute and elective surgeries was noted. There were fewer elective aortic cases completed during this lockdown period. This suggests the experience of decreased cardio-surgical volumes with concern for a build-up of a “backlog” of cardiac patients awaiting surgery, seen around the world, is unlikely to be mirrored



Graph 5. Pie graph showing distribution of adult cardiac surgery split by surgery type for March-April 2020. CABG, coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement; TVR, tricuspid valve replacement

here in New Zealand. There is the suggestion of a larger number of acute presentations requiring cardiac operations in late 2020 could be attributed to the decreased access to cardiology clinics and diagnostic services, such as angiogram and echocardiography, which largely were postponed during the lockdown period.

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