


Changing patterns in Australian and New Zealand: vascular surgery during COVID-19

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Key words

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Abstract

Background: Early government-mandated restrictions in Australia and New Zealand contributed to a successful public health outcome during the COVID-19 pandemic, including an unprecedented temporary cancellation of all non-urgent elective surgical procedures. This study describes the change in vascular surgery services across Australia and New Zealand before and during the COVID-19 restrictions.

Methods: De-identified data from the Australia and New Zealand Society for Vascular Surgery Australasian Vascular Audit from January 2015 to September 2020 was obtained. Vascular surgery procedure numbers from January to September of 2020 (study period) was compared to the corresponding months between 2015 and 2019 (pre-study period). The volume of procedures, both elective and emergency, were compared. Subgroup analyses included procedures categorized by operation type and location.

Results: There was a 11% decrease in total vascular procedures, 22% decrease in elective procedures, and a 14% increase in emergency procedures, comparing the study and pre-study periods. There was a large increase in all revascularization procedures for critical limb ischemia and no change in acute limb ischemia interventions, without a concomitant rise in major or minor all-cause amputation. There was a decrease in interventions for abdominal aortic aneurysm and carotid artery disease, driven by a fall in elective procedures, while volume for dialysis access remained the same. Change in procedural volume varied by state with the largest decrease noted in NSW and Victoria.

Conclusions: The COVID-19 pandemic reduced vascular surgery procedures across Australia and New Zealand with a decrease in elective operations and an increase in emergency operations.

Introduction

The COVID-19 pandemic has had a significant impact on the delivery of both Australian and global health care services.^{1,2} Cases continued to rise through 2020, and at the time of writing (March 2021) global case numbers were upwards of 123 million. However, despite a population of 24.99 million (3.2% of global population), cases in Australia and New Zealand at this point numbered 31 668 (0.03% of global cases). Strict government mandated social and healthcare restrictions including a hard border lockdown, and a restriction on community gatherings have been a key factor in the limit of the spread of COVID-19 in Australia and New Zealand. It should be noted that New Zealand enforced a comparatively swifter and stricter response than Australia. Another significant component of these was the cessation of all non-essential elective surgical

procedures including all category C patients (surgery required within 365 days) and most category B patients (surgery required in 90 days) in late March 2020.³ This is an unprecedented event of particular importance for vascular surgery, where a large proportion of procedures performed in Australia and New Zealand are for chronic limb ischemia, ranging from the revascularisation of critical limb threatening ischemia, which are typically allocated as category A, to treatment of claudication, which may be either category B or C.

It is likely that a large number of vascular surgery procedures were delayed or modified by COVID-19 restrictions, which has multiple implications. First, cancelling elective work results in backlog of procedures that, when normal surgical volumes are resumed, will need to be managed on top of standard procedural volume.⁴ Estimating this accumulation is essential to planning

future service provision. Second, the well-established principle of 'time is tissue' means that any delay in surgical intervention will likely have significant impact on patient outcomes. Specific to vascular surgery patients, this may mean more difficult revascularization procedures, more severe ulcers, or more irreversible ischaemia potentially leading to limb loss.⁵ The impact of these complications due to delay needs to be quantified to predict future demand on the healthcare system. Third, alterations in public health directives could impact the nature of vascular surgeries performed, for example the faster time to amputation without early complex revascularisation that has been reported in other healthcare systems.⁶ These alterations should be identified in order to make predictions for sustainable future surgical protocols. Finally, even after resumption of full operating capacity, patient attendance to outpatient clinics has not yet returned to pre-COVID-19 figures. This is both anecdotally recognized in Australia and New Zealand, but has also been demonstrated overseas.⁷

This study aims to describe the impact of COVID-19 on vascular surgery procedure numbers in Australia, with a direct comparison to procedural numbers from previous years. Specifically, this study investigated the proportion of elective and emergency vascular operations performed before, and during the initial restrictions of the current COVID-19 pandemic in Australia and New Zealand.

Methods

Data acquisition

Data for this study was obtained in de-identified format with permission from the Australia and New Zealand Society for Vascular Surgery (ANZSVS) Australasian Vascular Audit (AVA). Data included all vascular surgery procedures recorded in the AVA performed in public and private hospital across Australia and New Zealand between 01 January 2015 and 30 September 2020. The period between the months of January to September between 2015 and 2019 is referred to as the pre-study period, while the period between the months of January and September in 2020 is referred to as the study period. COVID-19 case numbers were extracted from publicly available data.⁸ AVA data is representative of all procedures performed by vascular surgeons in Australia and New Zealand, and has been previously shown to have a 63% capture rate, with high data accuracy (2.6% error rate).⁹ This research was conducted in accordance with the Declaration of Helsinki, and was approved by the Human Research Ethics Committee of the Sydney Local Health District.

Data and outcome measures

Demographic data included in the AVA data did not allow for patient identification, but did include patient age, state and country in which the operation took place. Surgical variables included date of operation, indication for operation, operation type (operative approach) and surgery type (elective, semi-urgent or emergency).

The primary study outcome was a comparison of the number of total, elective, and emergency vascular surgical procedures performed during the pre-study and study periods. Secondary outcomes were the total number of vascular surgical procedures by

state/country, operation type and month for these same periods. Included operation types were revascularization procedures for acute and critical limb ischemia, major and minor amputations, and operations for abdominal aortic aneurysms, carotid artery disease and dialysis access.

Surgery type allowed classification of a surgery as either elective, or emergent ('semi-urgent' or 'emergency'). Location was identified by the 'state' or 'country' variable. Treatment of acute limb ischemia was defined as 'acute limb ischemia' in the 'indication for surgery' variable, while critical limb ischemia was defined by either 'rest pain' or 'ulceration' as the indication for surgery in the context of 'chronic limb ischemia'. Selection of 'operation type' for these two conditions was limited to include only the revascularization and limb salvage options, and excluded management by means of amputation or fasciotomy alone. Major and minor amputations are defined as 'major amp' or 'minor amp' respectively, and included all-cause amputation for diabetic foot disease, peripheral vascular disease or trauma. Aortic aneurysm surgery was defined by 'indication for surgery' including any symptomatic or asymptomatic aortic aneurysm pathology in conjunction with 'operative site' specifying any open or endoluminal procedure performed on an aorta or aortoiliac vessels. Carotid artery surgery was defined specifically as asymptomatic carotid disease or TIA/stroke as 'indication for surgery' and 'operative site' at the carotid artery, not specifying whether an open or endovascular approach was taken. Table S1 summarizes the keywords used to categorize operation types.

Data analysis

Prior to analysis, study data was filtered in order to estimate procedural numbers for each subgroup of interest. Descriptive statistics including mean, standard deviation, median and quartiles were calculated for the primary outcome, and for each secondary outcome subgroup (Supplementary data 2). Two-tailed student's *T*-tests were performed on each variable to assess for significant difference between monthly averages between 2015–2019 and 2020. Significance was taken at $p < 0.05$. Time series analyses were conducted for each outcome and further analysed by month whereby monthly procedure numbers for the pre-study and study periods were calculated.

All data manipulation and analyses were conducted in R Statistics (R Core Team; R Foundation for Statistical Computing, Vienna, Austria) for processing and analysis. Figures were created in Microsoft Excel version 14.7.3 (Microsoft Corporation; New Mexico, USA) or R Statistics.

Results

Primary outcomes

Total procedures

For the entire data capture period between January 2015 and September 2020, a total of 243, 632 vascular surgery interventions were recorded in the Australasian Vascular Audit. Of these, 164, 773 (68%) were electively planned procedures, while 78, 859 (32%) were emergency procedures. For the pre-study period

Table 1 Monthly averages of total, elective, and emergency vascular surgery procedures data for 2015–2019 presented as monthly mean (standard deviation). Data for 2020 presented as procedure numbers (% difference compared to previous year average)

	Total		Elective		Emergency	
	2015–2019 Mean (SD)	2020 Total (change)	2015–2019 Mean (SD)	2020 Total (change)	2015–2019 Mean (SD)	2020 Total (change)
Jan	2785 (161)	2929 (+5%)	1793 (83)	1798 (+0%)	993 (88)	1131 (+14%)
Feb	3656 (113)	3824 (+5%)	2594 (89)	2501 (−3%)	1063 (68)	1323 (+24%)
March	3957 (171)	3538 (−11%)	2809 (152)	2204 (−22%)	1148 (69)	1334 (+16%)
April	3383 (152)	2437 (−28%)	2314 (112)	1177 (−49%)	1070 (66)	1260 (+18%)
May	3914 (149)	3071 (−22%)	2762 (130)	1727 (−37%)	1153 (70)	1344 (+17%)
June	3696 (150)	3531 (−4%)	2551 (169)	2185 (−14%)	1145 (47)	1346 (+18%)
July	3712 (166)	3453 (−7%)	2553 (91)	2215 (−13%)	1160 (111)	1238 (+7%)
Aug	3826 (177)	3170 (−17%)	2661 (202)	1923 (−28%)	1166 (101)	1247 (+7%)
Sept	3531 (111)	3047 (−14%)	2391 (88)	1830 (−23%)	1140 (107)	1217 (+7%)

Note: 2015–2019 data presented as monthly mean (standard deviation). 2020 data presented as procedure numbers (% difference compared to previous year average).

between 2015 and 2019, the yearly mean number of procedures was 32 462, compared to a total of 29 000 procedures during the study period in 2020. Thus, there was a decrease of 11% in overall procedures in 2020 (Table 1). The monthly mean number of procedures during the study period was significantly lower than the monthly mean number of procedures during the pre-study period (Table 2).

Elective versus emergency procedures

For the pre-study period, the yearly average number of elective procedures was 22 426 (69% of total) and emergency procedures was 10 036 (31% of total), while for the study period, there was 17 560 elective procedures performed (61% of total), and a total of 11 440 (39% of total). Thus, there was an overall 22% decrease in the total number of elective procedures, and a 14% rise in total emergency procedure numbers between the study and pre-study periods (Table 1). Comparison of percentage breakdown of elective and emergency procedures are shown in Figure 1(a).

The monthly mean number of elective procedures during the study period was significantly lower than the monthly mean number of elective procedures during the pre-study period, while the opposite was true for emergency procedures (Table 2).

Secondary outcomes

A comprehensive breakdown of procedure numbers by year (Table S2) and by month (Table S3), by operation type, and Australian state/territory and New Zealand is presented in the supplemental data.

Procedures by operation type

There was a significant monthly increase in total, elective, and emergency revascularization procedures for critical limb ischemia, and emergency major and minor amputations without an overall increase in total numbers. Contrastingly, there was an overall monthly decrease in elective major amputations, total and elective abdominal aortic aneurysm repair, and total and elective

Table 2 Comparison of monthly averages of total, elective and emergency vascular surgery procedures between for 2015–2019 and 2020

	2015–2019			2020			Diff		
	2015–2019 Mean (SD)	2020 Total	Diff	2015–2019 Mean (SD)	2020 Elective	Diff	2015–2019 Mean (SD)	2020 Emergency	Diff
All operations	3606 (367)	3222 (414)	−385*	2492 (315)	1951 (384)	−541**	1115 (94)	1271 (72)	+156**
CLI revasc	362 (67)	468 (58)	+106**	212 (41)	242 (33)	+30*	150 (33)	226 (30)	+76**
ALI revasc	91 (12)	100 (915)	+9						
Major amp	97 (12)	101 (10)	+4	26 (7)	17 (4)	−9**	71 (10)	84 (9)	+13**
Minor amp	234 (33)	256 (32)	+22	71 (14)	63 (13)	−8	163 (26)	193 (24)	+30**
Aortic aneurysm	180 (25)	146 (20)	−35**	143 (24)	114 (21)	−29**	37 (6)	32 (7)	−5
Carotid disease	157 (20)	122 (13)	−35**	93 (14)	60 (9)	−33**	64 (10)	62 (7)	−2
Dialysis access	428 (55)	431 (55)	+3	359 (54)	360 (41)	+1	70 (12)	71 (19)	+2
NSW	1068 (140)	898 (147)	−170**	752 (122)	585 (132)	−166**	316 (30)	313 (36)	−4
VIC	822 (92)	681 (126)	−142**	562 (80)	372 (111)	−190**	261 (21)	309 (40)	+48**
QLD	653 (65)	596 (100)	−57	464 (54)	390 (87)	−74*	188 (28)	205 (21)	+17
NZ	387 (47)	350 (62)	−36	240 (35)	187 (42)	−53**	147 (28)	163 (25)	+16
SA	230 (45)	242 (32)	+12	136 (24)	99 (33)	−37*	95 (32)	143 (8)	+49**
WA	290 (60)	293 (45)	+3	224 (46)	212 (43)	−12	66 (17)	81 (16)	+15*
TAS	53 (15)	70 (16)	+17*	38 (12)	49 (16)	+11	14 (7)	21 (5)	+7**
NT	13 (10)	17 (10)	+4	9 (8)	9 (7)	0	4 (4)	9 (7)	+5
ACT	91 (18)	75 (17)	−16*	67 (16)	27 (13)	−20**	24 (8)	48 (9)	+3

Note: Data presented as Mean (SD); * $p < 0.01$; ** $p < 0.001$.

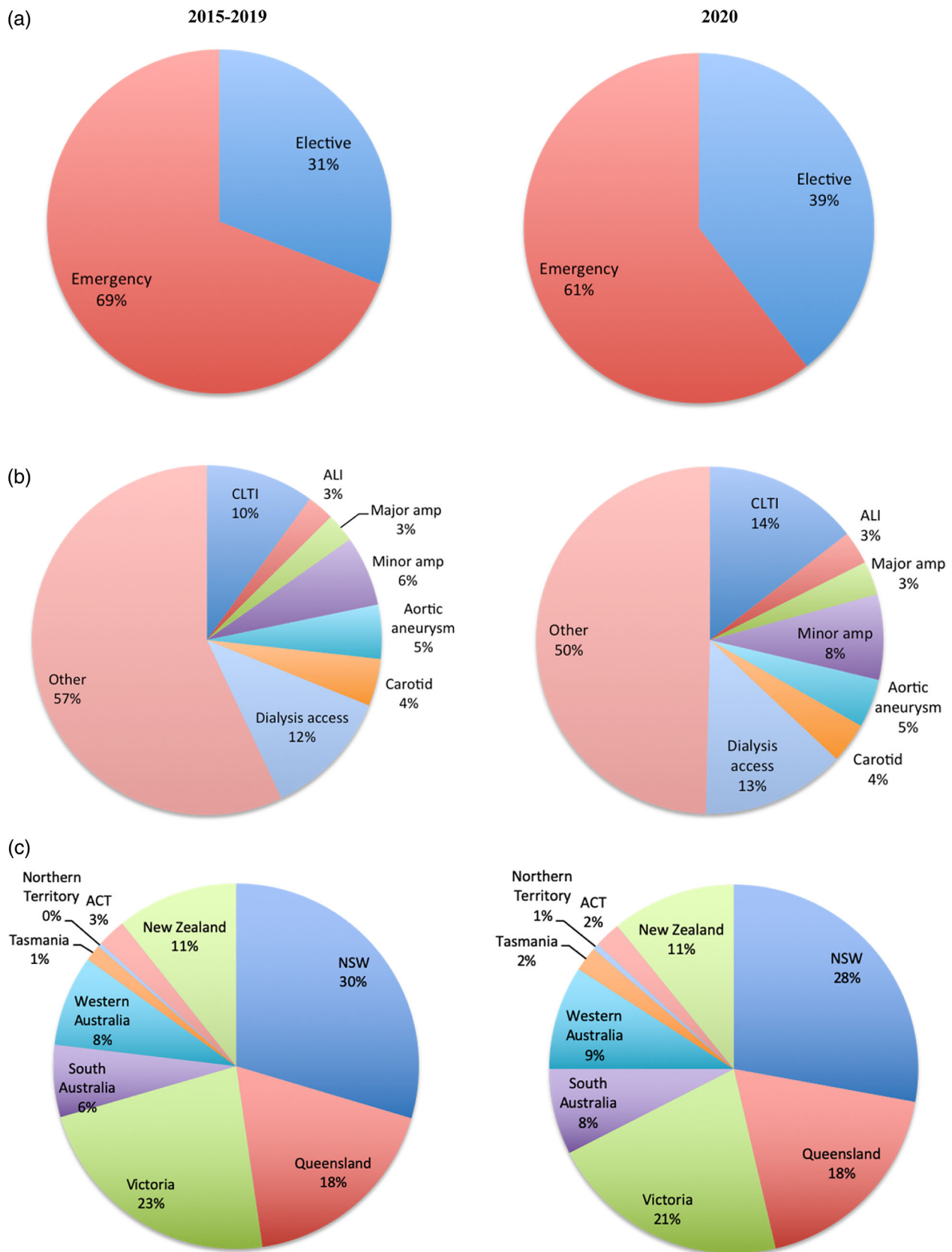
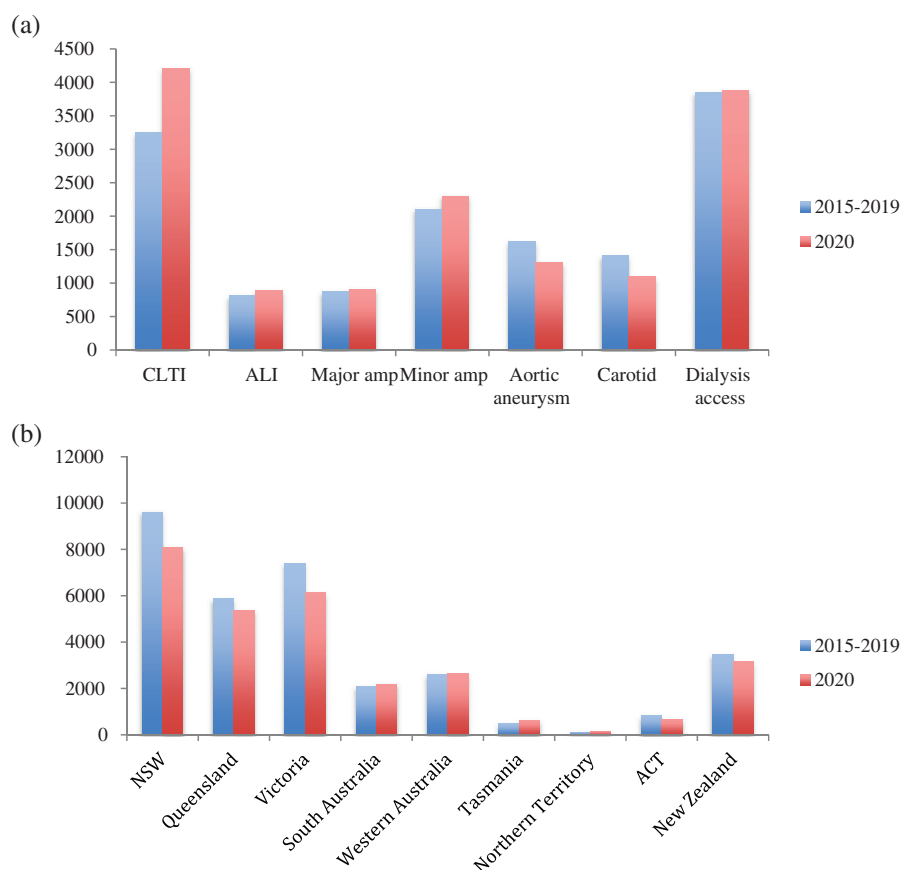


Fig 1. Graphical representation of procedure proportion between the 2015–2019 period and 2020. (a) Comparison between elective and emergent procedures. (b) Comparison between procedures based on procedure type. (c) Comparison between states/territories across Australia and New Zealand.

Fig 2. Comparison of operative procedure numbers by operation type (a) and Australian states/territories and New Zealand (b) comparing the 2015–2019 period to 2020.



intervention for carotid disease. Total and electively scheduled major and minor amputations, elective abdominal aortic aneurysm, and elective carotid artery disease operations did not significantly differ between the pre-study and study periods. There was no difference in the numbers of dialysis access procedures, total, elective or emergency, performed between these two time periods (Table 2). Comparison of procedure numbers by surgery type between the between the study and pre-study period is shown in Figures 1(b) and 2(a).

Procedures by Australian state/territory and New Zealand

There was a significant difference in total operations in NSW, Victoria, Tasmania and the ACT only, with only Tasmania noting an increase in overall operating numbers in 2020. Elective operating decreased in New Zealand, and across all Australian states/territories except Western Australia, Tasmania and the Northern Territory, while emergency operating was noted to have increased in Victoria, South Australia, Western Australia and Tasmania only. Comparison of percentage breakdown of procedures by state are shown in Figures 1(C) and 2(b).

Trend of procedures by month

From March 2020 onwards, the total number of vascular surgery procedures was reduced compared to 2015–2019 monthly averages (Table 1). The largest decrease was noted in April 2020 where the

total number of operations performed was 28% below monthly average.

Elective vascular surgery declined steeply from March to April of 2020 (–46%), and then incrementally increased for the subsequent months (April to May: +46%; May to June: +21%; June to July: +1%) before plateauing. Despite the decline then subsequent increase, the absolute procedure numbers remained low compared to the pre-study period monthly averages.

A similar pattern did not occur with emergency vascular surgery procedures, which remained relatively stable, with absolute procedure numbers fluctuating between 1260 and 1346 between March and July, with the least number of emergency operations performed in the month of April. Compared to the pre-study period however, the total number of emergency procedures performed each month in 2020 was above previous year monthly averages, with the largest increase in February.

A monthly time series plot of total procedures, elective procedures, and emergency procedures is presented in Figure 3.

Discussion

In the 6 months after the WHO recognition of COVID-19 as a global pandemic, global health service delivery changed significantly and still remains affected. In more heavily affected countries, cessation of non-urgent surgical services owing to the re-allocation of healthcare resources have led to a backlog pending elective

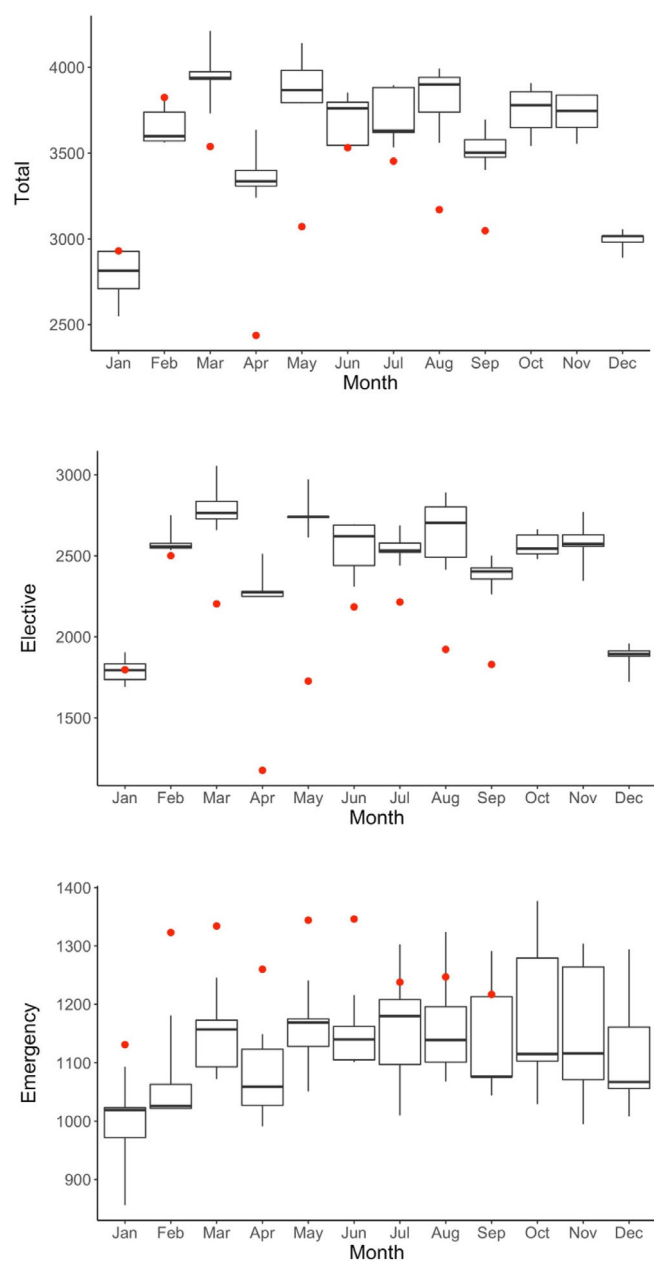


Fig 3. Total, elective, and emergency procedure numbers per month. Box and whisker plots represent monthly procedure numbers between 2015 and 2019. The red dot represents monthly procedure numbers in 2020. Whiskers represent monthly minimum and maximum numbers (outliers included), while the box represents median with first and third quartiles.

surgeries. For example, in the UK, it is estimated that nearly 10 million elective operations are currently waitlisted as of February 2021.¹⁰ However, swift government and local health district responses to the pandemic in Australia and New Zealand have minimized the healthcare impact of COVID-19 in these countries. In particular, during the early days of the pandemic, alongside an early hard border lockdown and restrictions placed on social gatherings, a nation-wide moratorium to all elective surgery was enforced, with a subsequent graduated re-introduction of elective operating as the severity of the situation was assessed (Fig. S1).¹¹ This study describes, the

impact of COVID-19 and temporary cancellation of elective surgery on vascular surgery procedures in Australia and New Zealand. There was a decrease in the total number of vascular surgery procedures performed, driven by a decreased number of elective procedures, which was notable across the more populous states/territories across Australia, and New Zealand.

We noted an increase in limb salvage procedures for critical lower limb arterial pathology in both the elective and emergent setting, without any difference to the number of revascularization procedures for acute limb ischemia. This came with a concomitant small rise in amputation numbers only in the emergency setting. There was, however, no overall difference in all-cause amputation between the pre-study and study periods, suggesting perhaps that although despite the overall increase in limb salvage operations performed, Australian and New Zealand vascular surgeons have successfully avoided an excess of major and minor amputations despite the impact of COVID. In comparison, data presented by Schuivens *et al.* in a single-centre study conducted in the Netherlands showed a significant increase from 8 and 5 major amputation cases in the March–April period of 2018 and 2019, respectively, to 15 in 2020, without significant change in other open vascular interventions performed.⁶ They reported a higher Rutherford grade for those who presented during the lockdown period. A similar increase in the number of major amputations have been described elsewhere, and have also been attributed to increased severity at presentation, associated with decreased clinic presentations and reduced case volumes.¹²

A survey of vascular surgeons and their practice in the United States notes that a majority of respondents reported prolonged cancellation of elective surgery during the COVID-19 pandemic, with the few who had continued operating noting a caseload shift primarily focused on dialysis access, aortic repair, and lower extremity limb salvage procedures.¹³ Our data similarly demonstrates that procedures for dialysis access and limb salvage were not reduced in the months surrounding the COVID-19 elective surgery cancellation. Contrastingly, procedure numbers for aortic repair markedly decreased during this time, and this may be attributed to the decrease in people with aortic conditions being unable to follow through with their vascular surgery referral due either directly (e.g. closure of outpatient clinics) or indirectly (e.g. travel restrictions) to COVID-related restrictions. This is similarly the case with carotid interventions. These numbers only refer to elective aortic and carotid work, as there was no difference in the emergent setting – for ruptured/symptomatic aortic aneurysm or symptomatic carotid artery disease. It is unclear what these figures mean for future trends, however expectations could include a general rebound in elective operating volume of untreated, undetected asymptomatic aortic and carotid pathologies at the treatment threshold, or perhaps a delayed increase in symptomatic emergent presentations of the same in the near future.^{14,15}

Finally, even after resumption of unrestricted full operating capacity, as has been the case in Australia and New Zealand towards the latter months of this study, the number of elective procedures has risen towards pre-study levels. Whilst there is a known backlog of elective surgical procedures, having cancelled or postponed an estimated 28 million elective operations worldwide, such

as hip and knee replacements, it is unclear whether this will similarly be the case for arterial vascular conditions, largely given the general acuity of vascular surgery as a specialty.^{10,16} Of the more common truly elective vascular procedures, varicose vein surgery is not mandatory to record in the AVA, and hence it is not accurately assessable through data collected in this study. Nevertheless, as patients return to normal living and attend routine follow-up, it should be expected that outpatient clinic visits and consequently elective surgical case numbers will increase over the coming year.⁷

One of the major study limitations is the quality of data entered within the AVA. The AVA is not a research-specific tool and was developed primarily to unify audit activities under the ANZSVS.¹⁷ It contains only limited data with regards to patient clinical details and operative details. Rather, only broad categorizations of operative indications, type of intervention and anatomical location of intervention are recorded. Moreover, though it does mandate entry of any peripheral arterial intervention, major amputations, aortic and carotid surgeries, data entry for elective varicose vein surgery, simple wound debridement and other smaller procedures are not necessary, and hence may be underestimated or unaccounted for. Furthermore, with focus on purely operative encounters, data regarding non-operative patient admission, clinical appointments, or procedures performed in a clinic setting are not included, and hence no conclusion can be drawn about these unless patient or hospital-level data are directly assessed. Lastly, maintenance of audit data especially at public hospitals is often the responsibility of the team registrar primarily for training and logbook purposes, and it is unclear how accurate data entry is at facilities without a vascular surgery trainee including at private hospitals. Validation of audit data is by a verification process of a randomly selected 5% of members per year.⁹

Although the immediate outcomes suggested by the present study have been largely positive, similar data collection and re-analysis at perhaps the 2 year mark at the end of 2021 (the projected period for the Australian and New Zealand vaccination program completion and potential re-introduction of international travel) would be useful to establish the longer term effects of COVID-19 associated changing patterns in vascular surgery practice during this COVID-19 era.

Conclusion

In Australia and New Zealand, COVID-19 associated restrictions reduced vascular surgery procedures across Australia and New Zealand. There was an increase in emergent and semi-urgent interventions, in particularly limb salvage, without a concomitant increase in amputation rates. There was a decrease in surgical management of aortic aneurysmal disease and carotid artery disease, which could lead to a higher rate complication and emergency surgery in these patients in future years though this has not been yet demonstrated. Dialysis access interventions remained commonplace and largely unchanged during the pandemic.

Conflict of interest

None declared.

Author contributions

Tommy Cai: Conceptualization; data curation; formal analysis; investigation; methodology; validation; visualization; writing – original draft; writing – review and editing. **Georgia Fisher:** Investigation; methodology; project administration; writing – review and editing. **Jacky Loa:** Methodology; project administration; supervision; writing – review and editing.

Data availability statement

Raw data were can be found on the Australasian Vascular Audit. Derived data supporting the findings of this study are available from the corresponding author TC on request.

References

1. Al-Jabir A, Kerwan A, Nicola M, Alsafi Z, Khan M, Sohrabi C, et al. Impact of the coronavirus (COVID-19) pandemic on surgical practice – part 2 (surgical prioritisation). *Int J Surg.* 2020;**79**:233–48.
2. Sutherland K, Chessman J, Zhao J, Sara G, Shetty A, Smith S, et al. Impact of COVID-19 on healthcare activity in NSW, Australia. *Public Health Res Pract.* 2020;**30**(4):3042030.
3. McBride KE, Brown KGM, Fisher OM, Steffens D, Yeo DA, Koh CE. Impact of the COVID-19 pandemic on surgical services: early experiences at a nominated COVID-19 Centre. *ANZ J Surg.* 2020;**90**(5):663–5.
4. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg.* 2020;**107**(11):1440–9.
5. Hincliffe RJ, Forsythe RO, Apelqvist J, Boyko EJ, Fitridge R, Hong JP, et al. Guidelines on diagnosis, prognosis, and management of peripheral artery disease in patients with foot ulcers and diabetes (IWGDF 2019 update). *Diabetes Metab Res Rev.* 2020;**36**(Suppl 1):e3276.
6. Schuivens PME, Buijs M, Boonman-de Winter L, Veen EJ, de Groot HGW, Buimer TG, et al. Impact of the COVID-19 lockdown strategy on vascular surgery practice: more major amputations than usual. *Ann Vasc Surg.* 2020;**69**:74–9.
7. Mehrotra A, Chernew M, Linetsky D, Hatch H, Cutler D. The impact of the COVID-19 pandemic on outpatient visits: a rebound emerges; 2020. <https://www.commonwealthfund.org/publications/2020/apr/impact-covid-19-outpatient-visits>.
8. Fairfacts Data. COVID-19 in Australia 2020. <https://www.covid19data.com.au/>.
9. Beiles CB, Bourke BM. Validation of Australian data in the Australasian vascular audit. *ANZ J Surg.* 2014;**84**(9):624–7.
10. The Lancet Rheumatology. Too long to wait: the impact of COVID-19 on elective surgery. *Lancet Rheumatol.* 2021;**3**(2):e83.
11. McNulty JM, Ward K. Suppressing the epidemic in New South Wales. *N Engl J Med.* 2020;**382**(21):e74.
12. Lancaster EM, Wu B, Iannuzzi J, Oskowitz A, Gasper W, Vartanian S, et al. Impact of the coronavirus disease 2019 pandemic on an academic vascular practice and a multidisciplinary limb preservation program. *J Vasc Surg.* 2020;**72**(6):1850–5.
13. Mouawad NJ, Woo K, Malgor RD, Wohlaer MV, Johnson AP, Cuff RF, et al. The impact of the COVID-19 pandemic on vascular surgery practice in the United States. *J Vasc Surg.* 2021;**73**(3):772–9.e4.
14. Adikari DH, Kushwaha VV, Jepson NS. Collateral damage: The cardiovascular cost of suppressing COVID-19 transmission in Australia. *Heart Lung Circ.* 2020;**29**(8):1109–11.
15. Moroni F, Gramegna M, Ajello S, Beneduce A, Baldetti L, Vilca LM, et al. Collateral damage: medical care avoidance behavior among

patients with myocardial infarction during the COVID-19 pandemic. *JACC Case Rep.* 2020;**2**(10):1620–4.

16. The Lancet Oncology. Valuing all lives equally: cancer surgery, COVID-19, and the NHS in crisis. *Lancet Oncol.* 2021;**22**(2):155.
17. Bourke BM, Beiles CB, Thomson IA, Grigg MJ, Fitridge R. Development of the Australasian vascular surgical audit. *J Vasc Surg.* 2012;**55**(1):164–9.

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Description and filter coding of each data subgroups-
Table S2. Yearly (January to September totals) surgical caseload of

total, elective, and emergency vascular surgery procedures by state/territory and by operation type **Table S3.** Monthly averages of total, elective, and emergency vascular surgery procedures by operation type, and by state/territory comparing the period between 2015–2019 against 2020 **Figure S1.** Comparison between COVID-19 cases in Australia and reduction in number of vascular surgery procedures performed. Top: Timeline of 2020 COVID-19 related key events in Australia (with particular note to events in Victoria). Middle: Cumulative number of COVID-19 cases in Australia in 2020. Bottom: Cumulative reduction in the number of vascular surgery procedures performed in 2020 compared to previous year (2015–2019) averages