Surgery Open Science 18 (2024) 129–133

Contents lists available at ScienceDirect

Surgery Open Science

journal homepage: www.journals.elsevier.com/surgery-open-science

Research Paper

The continued financial effect of COVID: Increasing costs for non-elective major lower extremity amputations

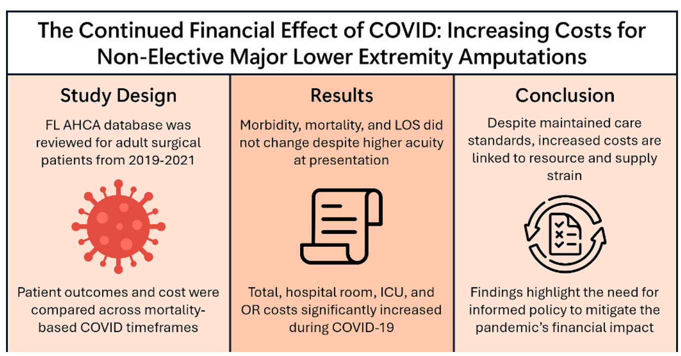
Johnathan V. Torikashvili [a], Meagan D. Read [a,b], Haroon M. Janjua [a], Rajavi Parikh [a], Paul C. Kuo [a], Emily A. Grimsley [a,*]

[a] Department of Surgery, University of South Florida Morsani College of Medicine, Tampa, FL, United States of America
[b] Department of Gastrointestinal Oncology, Moffitt Cancer Center, Tampa, FL, United States of America

HIGHLIGHTS

- Clinical and financial effects of COVID-19 pandemic have not been fully evaluated.
- No change in outcomes for non-elective lower-extremity amputation during pandemic
- Pandemic led to higher patient costs for non-elective lower extremity amputation.

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
COVID-19
Pandemic
Lower extremity amputation
Chronic limb ischemia
Vascular surgery

ABSTRACT

Background: The COVID-19 pandemic necessitated changes in processes of care, which significantly impacted surgical care. This study evaluated the impact of these changes on patient outcomes and costs for non-elective major lower extremity amputations (LEA).

Methods: The 2019–2021 Florida Agency for Health Care Administration database was queried for adult patients who underwent non-elective major LEA. Per-patient inflation-adjusted costs were collected. Patient cohorts were established based on Florida COVID-19 mortality rates: COVID-heavy (CH) included nine months with the highest mortality, COVID-light (CL) included nine months with the lowest mortality, and pre-COVID (PC) included nine months before COVID (2019). Outcomes included in-hospital patient outcomes and hospitalization cost.

Results: 6132 patients were included (1957 PC, 2104 CH, and 2071 CL). Compared to PC, there was increased patient acuity at presentation, but morbidity (31%), mortality (4%), and length of stay (median 12 [8–17] days) were unchanged during CH and CL. Additionally, costs significantly increased during the pandemic; median total cost rose 9%, room costs increased by 16%, ICU costs rose by 15%, and operating room costs rose by 15%. When COVID-positive patients were excluded, cost of care was still significantly higher during CH and CL.

* Corresponding author at: USF Morsani College of Medicine, Department of Surgery, 2 Tampa General Circle, Rm 7015, Tampa, FL 33606, United States of America.

E-mail address: grimsley@usf.edu (E.A. Grimsley).

https://doi.org/10.1016/j.sopen.2024.03.001
Received 4 March 2024; Accepted 6 March 2024
Available online 13 March 2024

Conclusions: Despite maintaining pre-pandemic standards, as evidenced by unchanged outcomes, the pandemic led to increased costs for patients undergoing non-elective major LEA. This was likely due to increased patient acuity, resource strain, and supply chain shortages during the pandemic.
Key message: While patient outcomes for non-elective major lower extremity amputations remained consistent during the COVID-19 pandemic, healthcare costs significantly increased, likely due to increased patient acuity and heightened pressures on resources and supply chains. These findings underscore the need for informed policy changes to mitigate the financial impact on patients and healthcare systems for future public health emergencies.

Introduction

The COVID-19 pandemic placed unprecedented challenges on society and fundamentally changed healthcare delivery. During the pandemic, there were numerous changes in processes of care in order to adequately care for patients with and without COVID-19. For example, the increased demand for essential resources, such as ventilators, staff, and space, profoundly decreased capacity for surgical care, resulting in restrictions on surgical delivery [1]. As a consequence of the pandemic, changes in processes of care meant altered treatment algorithms and care delivery and increased healthcare spending [2].

A notable factor contributing to the surge on healthcare spending includes the increased expenditures on surgical care, particularly for non-elective procedures. Hospitals faced the challenges of managing increased operational costs due to necessary safety protocols and resource allocation for COVID-19 care, while simultaneously experiencing a decline in revenue due to the suspension of elective surgical procedures [3]. This situation was compounded by higher expenses related to personal protective equipment (PPE) [4] and modified treatment strategies, leading to an increase in spending [2]. These shifts in healthcare delivery, necessitated by the pandemic, likely contributed to changes in clinical outcomes and healthcare costs for patients undergoing non-elective surgeries, including lower extremity amputations.

Increasing healthcare spending and significantly altered processes of care during the pandemic bring into question patient outcomes, particularly surgical patients. As a common non-elective operation, major lower extremity amputations provide a suitable patient cohort to compare pre-COVID to pandemic outcomes and has not been previously evaluated. Thus, this study aims to assess how changes in processes of care during the COVID-19 pandemic affected the clinical course for patients undergoing non-elective major lower extremity amputation by examining clinical outcomes and cost.

Methods

The Florida Agency for Health Care Administration (FL AHCA) inpatient data was retrospectively reviewed for adult (≥18 years old) patients who underwent non-elective major lower extremity amputation (below-knee, through-knee, or above-knee) from 2019 to 2021. This database provides patient-level data including patient demographics, diagnosis and procedure codes, and individual patient charges per hospitalization. Patients were excluded if: 1) admission was not urgent/emergent, 2) they were transferred from an ambulatory surgery center, or from a hospice, or 3) they had missing necessary data. The principal International Classification of Disease, Version 10 (ICD-10) Procedure Code defined the included lower extremity amputation procedures (Supplemental Table I). The choice to focus on non-elective lower extremity amputation in this study was driven by our aim to analyze a subsect of emergency surgery, considering the underutilization of non-emergent procedures during the pandemic. Amputation, being a relatively common procedure, provided a large enough sample size to yield robust results. Patient demographics, comorbidities, and acute conditions present on admission were recorded. Patients with age defined as "age 100 and older" were reassigned to an age of 100. Charlson Comorbidity Index [5] was tabulated. Acute COVID-19 infection (COVID-positive) was denoted via the presence of ICD-10 diagnosis code U.071 or J.1282.

The Centers for Disease Control and Prevention COVID-19 mortality data was used to identify three-month quarters with the highest and lowest COVID mortality in the state of Florida [6]. Quarters were utilized as that is how patients are categorized within FL AHCA. The three quarters with the highest COVID mortality were labeled COVID-heavy (CH). Those with the lowest mortality were deemed COVID-light (CL). The first three quarters of 2019 were used as the pre-COVID (PC) control.

Clinical outcomes included in-hospital mortality, morbidity, and length of stay (LOS). LOS is presented as median (interquartile range [IQR]). Finally, the cost of admission per patient was determined. Cost was calculated by multiplying individual charges provided in FL AHCA by previously established Centers for Medicare and Medicaid (CMS) cost-to-charge ratios [7,8]. Room, intensive care unit (ICU), operating room (OR), and total costs were calculated. Costs were adjusted for inflation using consumer price index, where 2021 was used as the index year.

Patient outcomes were compared between the three timeframes. Univariate analysis utilized Chi-square, Kruskal-Wallis, and ANOVA with post-hoc tests. Results were considered significant if p values < 0.05. Stata software version 17 (StataCorp, College Station, TX) was used for all data preparation and analysis. This study was deemed exempt from the Institutional Review Board as it utilized solely deidentified data.

Results

Overall, 7817 patients met inclusion criteria. Patients were excluded for elective (n = 1464) or trauma (n = 193) admission type, admission from an ambulatory surgery center or transfer from hospice (n = 23), and missing data (n = 5). There were no significant differences in excluded patient number based on timeframe. 6132 patients were included: 1957 PC, 2104 CH, and 2071 CL. There were no patients who had bilateral amputations. Demographics, comorbidities, and acute conditions present on admission can be found in Table I. Notably, during CL more patients had history of peripheral vascular disease. Compared to PC, more patients in CH had dementia, rheumatic disease, and uncomplicated diabetes and more often presented with sepsis, acute kidney injury, and electrolyte/acid-base disorders. Compared to PC, more patients in CL had peripheral vascular disease and uncomplicated diabetes and more often presented with sepsis, acute kidney injury, and electrolyte/acid-base disorders (Table I). There were 110 COVID-positive patients in CH and 59 in CL (3% of patients overall).

There was no increase in LOS, mortality, or overall morbidity during COVID timeframes. Overall, 31% of patients experienced a complication, and the mortality rate was 4%. The median LOS was 12 [8–17] days. There was a significant decrease in rate of ICU admission during CH, compared with PC (Table II). Individual complication rates are also noted in Table II, though there were no significant differences except lower rates of acute kidney injury in CH, compared with PC and CL (5 vs. 7 PC and 7% CL, p = 0.04). During CH, more patients were discharged home with home health services than in PC or CL (18 vs. 14 PC and 15% CL, p < 0.01). This increase in home health discharges was met with a decrease in discharge to skilled nursing facilities during CH (40 vs. 44 PC and 43% CL, p = 0.01; Table II).

Table I
Patient demographics.

	Pre-COVID (n = 1957)	COVID-heavy (n = 2104)	COVID-light (n = 2071)	p-Value
Sex				0.06
Female	704 (36%)	728 (35%)	672 (32%)	
Male	1253 (64%)	1376 (65%)	1399 (68%)	
Age*	64.7 (13.5)	64.6 (13.1)	65.2 (13)	0.25
Race				0.03[a]
White	1223 (63%)	1374 (65%)	1356 (66%)	
Black	592 (30%)	555 (26%)	546 (26%)	
Other	142 (7%)	175 (8%)	169 (8%)	
Hispanic-Latino	304 (16%)	328 (16%)	313 (15%)	0.90
Insurance				0.12
Medicare	1316 (67%)	1374 (65%)	1404 (68%)	
Private	182 (9%)	246 (12%)	194 (9%)	
Government	47 (2%)	53 (3%)	61 (3%)	
Medicaid	319 (16%)	345 (16%)	332 (16%)	
Other	28 (1%)	19 (1%)	28 (1%)	
Self-pay	65 (3%)	67 (3%)	52 (3%)	
Charlson Comorbidity Index*	3.6 (2.0)	3.6 (2.0)	3.7 (2.0)	0.11
Comorbidities				
Myocardial infarction	48 (3%)	57 (3%)	64 (3%)	0.46
Congestive heart failure	593 (30%)	640 (30%)	686 (33%)	0.09
Peripheral vascular disease	713 (36%)	826 (39%)	837 (40%)	0.03[b]
Stroke	56 (3%)	75 (4%)	60 (3%)	0.34
Dementia	199 (10%)	264 (13%)	222 (11%)	0.04[c]
Chronic pulmonary disease	456 (23%)	467 (22%)	470 (23%)	0.70
Rheumatic disease	49 (3%)	77 (4%)	49 (2%)	0.02[d]
Mild liver disease	87 (4%)	101 (5%)	96 (5%)	0.87
Severe liver disease	16 (1%)	12 (1%)	14 (1%)	0.63
Uncomplicated diabetes	1080 (55%)	1237 (59%)	1219 (59%)	0.03[a]
Complicated diabetes	1246 (64%)	1318 (63%)	1337 (65%)	0.44
Renal disease	864 (44%)	863 (41%)	919 (44%)	0.05
Present on admission				
Sepsis	280 (14%)	350 (17%)	357 (17%)	0.03[a]
Deep vein thrombosis	76 (4%)	76 (4%)	86 (4%)	0.66
Acute kidney injury	475 (24%)	592 (28%)	602 (29%)	<0.01[a]
Electrolyte/acid-base disorder	700 (36%)	945 (45%)	947 (46%)	<0.01[a]
COVID-19 infection	0 (0%)	110 (5%)	59 (3%)	<0.01[e]

All values displayed as n (%) unless otherwise noted.
* Displayed as mean (SD).
[a] PC vs. CH and CL, $p < 0.05$.
[b] PC vs. CL, $p < 0.01$.
[c] PC vs. CH, $p < 0.05$.
[d] CH vs. PC and CL, $p < 0.05$.
[e] All pairwise comparisons, $p < 0.01$.

All costs significantly increased during the pandemic. The median total cost in PC was $21,421; this increased by 9% during the pandemic. Room costs increased by 16% from a PC median of $1783. Additionally, ICU costs increased by 15% from a PC median of $3620, and OR costs increased by 15% from a PC median of $3855 (Table III).

Of note, when COVID-positive patients were excluded (demographics in Supplemental Table II), there was a lower rate of composite complication during CH vs. PC and CL (28 vs. 32 CH and 32% CL, $p = 0.02$; Supplemental Table III). There were no significant changes in cost (Supplemental Table IV).

Discussion

This retrospective cohort study assessed how changes in processes of care associated with the COVID-19 pandemic affected patient outcomes and cost for non-elective major lower extremity amputation. When compared with pre-COVID, this study found increased severity of patients at presentation, but no difference in morbidity, in-hospital mortality, nor prolonged LOS. However, patient costs rose significantly during the pandemic.

Table II
Patient outcomes.

	Pre-COVID (n = 1957)	COVID-heavy (n = 2104)	COVID-light (n = 2071)	p-Value
Multiple amputations	98 (5.0%)	158 (8%)	125 (6%)	<0.01[a]
LOS in days^	12 (8–17)	11 (8–17)	12 (8–18)	0.03[b]
In-hospital mortality	74 (4%)	74 (4%)	77 (4%)	0.90
Any complication	626 (32%)	618 (29%)	662 (32%)	0.11
ICU admission	959 (49%)	935 (44%)	976 (47%)	0.01[a]
Complications				
Pneumonia	959 (49%)	935 (44%)	976 (47%)	0.62
Pleural effusion	27 (1%)	30 (1%)	26 (1%)	0.89
Respiratory failure	152 (8%)	153 (7%)	151 (7%)	0.80
Arrhythmia	54 (3%)	62 (3%)	66 (3%)	0.72
Myocardial infarction	25 (1%)	28 (1%)	24 (1%)	0.88
Cardiac arrest	35 (2%)	49 (2%)	38 (2%)	0.39
Sepsis	99 (5%)	83 (4%)	106 (5%)	0.13
Urinary tract infection	34 (2%)	43 (2%)	37 (2%)	0.74
Deep vein thrombosis	24 (1%)	29 (1%)	32 (2%)	0.69
Delirium	24 (1%)	21 (1%)	28 (1%)	0.56
Acute kidney injury	134 (7%)	109 (5%)	141 (7%)	0.04[c]
Electrolyte/acid-base disorder	344 (18%)	339 (16%)	366 (18%)	0.33
Discharge destination				
Home (without services)	151 (8%)	156 (7%)	164 (8%)	0.83
Home with home health	271 (14%)	384 (18%)	319 (15%)	<0.01[c]
Transferred	48 (3%)	39 (2%)	30 (1%)	0.06
Nursing facility	858 (44%)	832 (40%)	892 (43%)	0.01[c]
Inpatient rehabilitation	458 (23%)	487 (23%)	485 (23%)	0.97
Left against medical advice	13 (1%)	20 (1%)	19 (1%)	0.56
Hospice	74 (4%)	74 (4%)	77 (4%)	0.90
Other*	10 (1%)	13 (1%)	9 (0%)	0.71

All values displayed as n (%) unless otherwise noted. LOS = Length of stay. ICU = Intensive care unit.
^ Displayed as median (IQR).
[a] PC vs. CH, $p < 0.01$.
[b] CH vs. CL, $p < 0.01$.
[c] CH vs. PC and CL, $p < 0.05$.
* Other includes discharge to jail, psychiatric facility, or other facility not otherwise specified.

During the COVID-19 pandemic, a multitude of changes in care processes were implemented to appropriately care for patients with and without COVID-19 and to ensure sufficient supply and staffing in a critical time. Resulting changes also included reduced in-person clinic visits, surveillance of chronic conditions, and non-emergent surgery. The lack of significant increase in morbidity, mortality, and LOS compared to pre-COVID found in this study is in accordance with the findings of Reinke et al., who reported no significant increase in mortality or LOS for patients undergoing non-elective general surgery during the COVID-19 pandemic [9]. Also echoed in prior literature, these findings suggest pre-pandemic care standards were able to be maintained, despite vast changes to healthcare delivery [10].

The most interesting finding of this study is the significantly increased cost per patient during the pandemic, which, to our knowledge, has thus far not been reported for surgical patients. Notably, our increased cost findings are not attributable to increased cost for COVID-

Table III
Per-patient cost.

	Pre-COVID (n = 1957)	COVID-heavy (n = 2104)	COVID-light (n = 2071)	p-Value
Total cost	21,421.1 (14,403.6–33,326.3)	23,128.9 (15,499.5–35,568.6)	23,566.7 (16,233.8–38,645.8)	<0.01[a]
Room cost	1,782.5 (292.4–3,769.9)	2,053.5 (496.7–4,262.4)	2,088.0 (440.0–4,293.0)	<0.01[b]
ICU cost	3,620.8 (1,897.4–6,650.2)	4,076.0 (1,720.5–7,345.5)	4,283.3 (2,043.9–8,133.5)	0.01[c]
OR cost	3,855.4 (2,608.0–6,403.6)	4,464.0 (2,977.6–7,017.4)	4,431.3 (2,976.9–7,467.9)	<0.01[b]

All values displayed in US dollars, as median (IQR). ICU = Intensive Care Unit. OR = Operating room.
[a] All pairwise comparisons, $p < 0.05$.
[b] PC vs. CH and CL, $p < 0.01$.
[c] PC vs. CL, $p < 0.01$.

positive patients, as these findings held when COVID-positive patients were excluded. While it is difficult to isolate a single cause for increased cost, a likely instigating factor was increased expenditures during the pandemic. In 2020, hospital spending reached $1.3 trillion (an increase of 6% from 2019) and spending for physicians and clinical services increased by 5% [2].

Increased hospitalization cost during the pandemic were likely driven by significantly increased PPE requirements, as well as concomitant staffing shortages. Unfortunately, due to increased demand, there were significant PPE shortages that led to rapidly rising supply costs [2,11]. Staffing shortages led to the addition of per diem staff, or so-called 'travelers,' at significantly higher cost.

The finding of increased total hospital costs is significant as it underscores the financial impact of the pandemic on healthcare systems, beyond the direct costs of treating COVID-19 patients. It highlights the need for emergency planning and resource allocation strategies to manage crises if they occur again in the future. The increased costs during the pandemic are likely multifactorial. Patients did present with higher acuity during the pandemic and had more staged amputations during CH, which may have driven cost increases. However, given no significant increase in morbidity, mortality, or LOS during the pandemic, it is likely that some of the cost increase was due to the healthcare system's response to the pandemic and increased equipment costs. Understanding these cost drivers can inform policy decisions and prevent patients from taking the burden of future public health emergencies, not only on their physical health but also on their financial well-being.

An interesting finding was significantly shorter LOS for CH, compared with CL, but no difference with PC. When COVID-positive patients were excluded, there was also a significant difference between CH and PC. We hypothesize that during peaks in the pandemic, the increased patient load in hospitals encouraged early hospital discharge. Further work with post-discharge follow-up data would be of benefit to determine if this shortened LOS impacted post-discharge patient outcomes.

Limitations of this study include the inherent biases associated with retrospective analysis. Additionally, due to the nature of databases, the results depend on the accuracy and availability of the reported data. For example, FL AHCA does not provide the ability to follow a patient longitudinally over multiple visits or after hospital discharge, and, therefore, only in-hospital mortality and morbidity can be reported. Another potential limitation stems from including COVID-positive patients in the analysis, though they were a small proportion of the sample and excluding them did not drastically change the findings of this study. Additionally, COVID timeframes were determined based on reported COVID-19 mortality rates in the state of Florida. Reporting of mortalities did change throughout the pandemic and may affect the accuracy of these rates. However, our results as a whole identify differences within the overall COVID timeframes, when compared to pre-COVID and thus remain reliable and interpretable. Finally, we did not exclude patients who had multiple lower extremity amputations during their hospitalization. Staged amputations were more common in CH vs. PC, and when COVID-positive patients were excluded, CH was significantly higher than PC and CL. Given there were significantly higher costs for CH and CL, compared with PC, but no difference in staged amputations between CL and PC, we do not believe the increased costs are solely attributable to increased staged amputations during the pandemic.

Conclusion

Despite significant changes in processes of care during the COVID-19 pandemic and increased patient acuity, there was no change in overall patient outcomes after non-elective lower extremity amputation. However, patients did experience significantly increased costs, which is likely attributed to increased acuity, resource strain, and supply chain disruption experienced during the pandemic.

Ethics approval

The study received an exemption from the Institutional Review Board due to its use of deidentified data.

Meeting presentation

This project was presented as an oral presentation at the Midwest Surgical Association annual meeting on August 1, 2023.

Funding statement

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

CRediT authorship contribution statement

Johnathan Torikashvili: Data curation, Writing – original draft, Writing – review & editing, Investigation, Visualization. **Meagan D. Read:** Data curation, Formal analysis, Methodology, Investigation. **Haroon M. Janjua:** Data curation, Formal analysis, Methodology. **Rajavi Parikh:** Conceptualization, Methodology, Supervision, Writing – review & editing, Validation. **Paul C. Kuo:** Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing, Software. **Emily A. Grimsley:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing, Investigation, Supervision, Visualization.

Declaration of competing interest

This study did not receive any extramural funding nor do any authors have conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2024.03.001.

References

[1] Søreide K, Hallet J, Matthews JB, et al. Immediate and long-term impact of the COVID-19 pandemic on delivery of surgical services. Br J Surg 2020;107(10):1250–61.

[2] Hartman M, Martin AB, Washington B, et al. National health care spending in 2020: growth driven by federal spending in response to the COVID-19 pandemic. Health Aff (Millwood) 2022;41(1):13–25.

[3] Mazzaferro DM, Patel V, Asport N, Stetson RL, et al. The financial impact of COVID-19 on a surgical department: the effects of surgical shutdowns and the impact on a health system. Surgery Dec 2022;172(6):1642–50. https://doi.org/10.1016/j.surg.2022.08.014 [Epub 2022 Aug 19. PMID: 36123177; PMCID: PMC9388446].

[4] Mena Lora A, Ali M, Spencer S, et al. Cost of personal protective equipment during the first wave of COVID-19. Antimicrob Steward Healthc Epidemiol Jul 29, 2021;1 (Suppl. 1):s49. https://doi.org/10.1017/ash.2021.94 [PMCID: PMC9551446].

[5] Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care 2005;43(11):1130–9.

[6] Centers for Disease Control and Prevention. Trends in number of COVID-19 cases and deaths in the US reported to CDC, by state/territory. In: COVID data tracker; 2021.

[7] Bai G, Anderson GF. Extreme markup: the fifty US hospitals with the highest charge-to-cost ratios. Health Aff (Millwood) 2015;34(6):922–8.

[8] Centers for Medicare and Medicaid Services. Cost reports. Available from: https://www.cms.gov/research-statistics-data-and-systems/downloadable-public-use-files/cost-reports. [Accessed 3 February 2023].

[9] Reinke CE, Wang H, Thompson K, et al. Impact of COVID-19 on common non-elective general surgery diagnoses. Surg Endosc 2023;37(1):692–702 [Erratum in: Surg Endosc. 2022;36(10):7861].

[10] Grimsley EA, Janjua HM, Read MD, Kuo PC. COVID-induced alterations in surgical care and outcomes in perforated diverticulitis. Am Surg 2023;89(9):3721–6. https://doi.org/10.1177/00031348231173935.

[11] Livingston E, Desai A, Berkwits M. Sourcing personal protective equipment during the COVID-19 pandemic. JAMA 2020;323(19):1912–4.