PERIODICUM BIOLOGORUM
VOL. 125, No 3–4, 223–228, 2023
DOI: 10.18054/pb.v125i3-4.25489

UDC 57:61
CODEN PDBIAD
ISSN 0031-5362

Original Research Article

Increased number of ruptured aortic aneurysms during SARS-CoV-2 pandemic

JOSIP FIGL
DINO PAPEŠ
IVAN ŠKORAK
TOMISLAV MEŠTROVIĆ*
IVAN ROMIĆ
SUZANA FIGL
PREDRAG PAVIĆ

Department of Surgery, University Hospital Center Zagreb, Zagreb, Croatia

***Correspondence:**
Tomislav Meštrović
E-mail address: mestrovic.tomislav@gmail.com

List of non-standard abbreviations

COVID-19	– coronavirus disease 2019
RAAA	– ruptured abdominal aortic aneurysm
SARS-Cov-2	– severe acute respiratory syndrome coronavirus 2
PHEIC	– public health emergency of international concern

Keywords: pandemic; SARS-CoV-2; ruptured abdominal aortic aneurysm; vascular surgery

Abstract

Background and purpose: *The aim of the study was to verify whether ongoing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic or Coronavirus disease (COVID-19) vaccination has any influence on established increased number of ruptured aortic aneurysms (RAA) during SARS-CoV-2 pandemic (years 2020-2021) regarding two-year of pre-pandemic period (2018-2019).*

Materials and methods: *Medical records of patients treated for the ruptured abdominal aortic aneurysm (RAAA) by surgical or endovascular reconstruction at the Department of Surgery, University Hospital Center Zagreb, between 2018 and 2021, were retrospectively analyzed. Categorical variables were analyzed using Fisher's exact test, while numerical variables were analyzed using Student's t-test or Mann-Whitney U test, depending on the normality of the distribution.*

Results: *The analysis revealed an increase in number of RAAAs by 55.56% in pandemic time (28 versus 18 in pre-pandemic years), decrease in their 30-day mortality by 18.65 % (53.57% vs. 72.22% respectively) and decrease in outpatient examinations during pandemic by 13.82%, but the differences were not statistically significant.*

Conclusion: *No statistically significant relation between SARS-CoV-2 pandemic or the COVID-19 vaccination and the number of treated RAAAs could be established. History of COVID-19 positivity or vaccination were not associated with RAAA outcome. The increase of RAAAs in pandemic along with decrease of its 30-day mortality compared to pre-pandemic time suggests patients' hesitance to go to elective surgery and avoidance of regular check-ups in the hospitals, where lots of patients with SARS-CoV-2 are presumed to be concentrated, since hospital service policy and protocols remained the same. The patients were never directly asked to answer this question, so even if the fear of getting SARS-CoV-2 infection remains the most plausible answer, it should be verified by an independent survey.*

Received February 16, 2023
Revised September 25, 2023
Accepted September 28, 2023

INTRODUCTION

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic is a severe, globally widespread infectious disease that affects all aspects of human life and has become a major public health problem. The World Health Organization (WHO) declared a public health emergency of international concern (PHEIC) on 30 January 2020 and ended its declaration on 5 May 2023, but the disease has still been spreading and, as of 24 September 2023, it had caused 770,777,632 cases and 6,958,486 confirmed deaths, ranking it fifth deadliest epi-

demic/pandemic in history *(1)*. The COVID-19 pandemic has been followed by mass media reports about the critical health situation in the world and appealing for safety, working from home and social distancing. A decrease in the number of emergency department patients has also been observed globally *(2-4)*.

Meanwhile, aneurysms of abdominal aorta, have never ceased to be serious vascular surgical conditions that require regular ambulatory monitoring and timely endovascular or open surgical treatment to avoid rupture and achieve an optimal reconstructive result.

A ruptured abdominal aortic aneurysm (RAAA) is, along with infection of the vascular prosthesis and major amputation, one of the most devastating and life-threatening complications for vascular surgery patient. It requires urgent surgical treatment and does not raise the question of whether there is a pandemic time or not. It puts the surgeon in the unenviable situation of trying to save someone else's life and thereby possibly endangering his own due to a profoundly serious, previously unknown, highly contagious, and life-threatening virus.

During a PHEIC period, to reduce the risk of SARS-CoV-2 infection, patients were required to adhere to national public health guidelines, isolation and quarantine. In this way, they avoided going to the hospital without a valid reason *(2,4-6)*, and thus skipped some regular check-ups, which might have contributed to an increased number of RAAAs, and major amputations compared to the period before the pandemic *(7-9)*.

Not only patients, but also hospitals and their employees had to reorganize and adapt to the new, delicate situation *(4)*. This reorganization in the pre-hospital emergency service and in hospitals inevitably led to the subordination of their basic activity to the emerging pandemic. All resources were focused on the substantial number of critically ill patients with SARS-CoV-2 infection. This necessarily led to other emergencies being put on the back burner *(3-5)*. But despite such a situation, all emergency services that arrived at our hospital, including the RAAAs, received timely and high-quality treatment as if there had been no pandemic.

This study was conducted to determine whether the SARS-CoV-2 pandemic or COVID-19 vaccination had influence on increased number of RAAs observed at our institution during the pandemic. We did not find similar studies in literature.

MATERIALS AND METHODS

In this retrospective, single-center study, we evaluated number of RAAAs that underwent open surgical or endovascular reconstruction at the Department of Vascular Surgery, University Hospital Center Zagreb, Croatia, EU, in SARS-CoV-2 pandemic two-year-period (January 1, 2020 – December 31, 2021) and compared it with a similar pre-pandemic time (January 1, 2018 – December 31, 2019). We also compared the numbers of RAAAs between the two pandemic years – 2020, when no Coronavirus disease (COVID-19) vaccine was available and 2021, when COVID-19 vaccination was discovered and put in use.

Patients' characteristics and comorbidities (COVID-19 disease or positivity, vaccination status, age, gender, coronary or peripheral arterial disease, chronic obstructive pulmonary disease, chronic heart failure, dementia, previous stroke, hypertension, hyperlipidemia, diabetes, aneurysm diameter), year and season of rupture, as well as the amount of transfused red blood cells, colloids and plasma, were analyzed.

Differences in discrete (categorical) variables were analyzed using Fisher's exact test. Continuous variables were tested for normality of distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. Differences in normally distributed continuous variables were tested for differences using Student's t-test, while the continuous variables that were not normally distributed were tested using Mann-Whitney U test. Statistical analyses were performed in R 4.3.1. *(10)*.

The study was conducted according to the principles outlined in the Declaration of Helsinki and informed consent was obtained for every patient.

RESULTS

In the observed pandemic period, we recorded a 55.56% increase in number of RAAAs in comparison to pre-pandemic period (28 vs 18), while the number of elective aortic aneurysm repair surgeries remained similar (109 vs 100), but the observed increase in number of RAAAs relative to elective aneurysm repairs was not statistically significant (Figure 1).

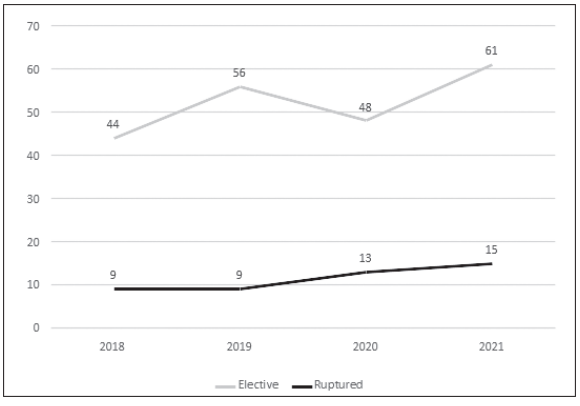

Figure 1. *Number of elective and ruptured aortic aneurysm repairs from 2018 to 2021. The difference in number of RAAA repairs between pre-pandemic (2018-2019) and pandemic (2020-2021) was evident, but not statistically significant (Fisher's exact test, p-value = 0.3285).*

Table 1. *Outpatient number in vascular, general and emergency surgery in pre-pandemic (2018–2019) and pandemic (2020–2021) times.*

Outpatient visits	Pre-pandemic time	Pandemic time
Vascular surgery	10641	9490
General surgery	8287	6491
Emergency surgery	62195	53919
Total	81123	69900

A 10.82% decrease was noted in the number of vascular outpatient visits in pandemic time in comparison with pre-pandemic time, a 21.67% decrease in number of general surgical outpatient visits, and 13.31% decrease in the number of emergency department visits, all together making for a general decrease of 13.83% in outpatient examinations (Table 1).

In the pre-pandemic period, the 30-day mortality of RAAs amounted to 72.22% vs. 53.57% in pandemic period, but the difference was not statistically significant (Table 2). We found no significant difference in comorbidity-related 30-day mortality between these two groups.

We further divided the pandemic period in two subgroups – year 2020 (before the COVID-19 vaccination period) and year 2021 (COVID-19 vaccination period). In 2020 the 30-day mortality was 53.84% versus 53.33% in 2021 and the difference was not statistically significant (Table 3).

No RAA patient in 2020 was COVID-19 vaccinated at the time of the surgery and 40% of RAA-patients in 2021 were COVID-19 vaccinated. The proportion of vaccinated patients among deceased patients (30-day mortality) was 25% in 2021 (Table 4), but there was no statistically significant difference in mortality between the vaccinated and non-vaccinated patients.

Irrespective of pandemic, significantly higher mortality was associated only with the amount of transfused fresh frozen plasma out of all univariately analyzed variables (Table 5), while other surgery-related and seasonal variables, as well as patient's characteristics and comorbidities, showed no statistically significant difference.

DISCUSSION

The decrease in 30-day mortality during the pandemic could be explained by a possible reduced level of pre-

Table 2. *30-day mortality in patients operated for RAAA during pre-pandemic and pandemic times (overall and depending on patients' characteristics).*

Patients operated for RAAA and their characteristics	Pre-pandemic time		Pandemic time		Significance
Number of patients	Operated	30-day mortality	Operated	30-day mortality	p-value (Fisher's exact test)
ALL	18	13	28	15	0.628
Hypertension	14	11	27	14	0.445
Hyperlipidemia	1	1	8	5	1
Coronary artery disease	5	4	6	2	0.62
Diabetes mellitus	1	1	6	2	1
Chronic renal failure	15	10	19	12	1
Chronic obstructive lung disease	2	2	6	4	1
Smoking	7	6	15	8	0.723
Male	18	13	20	12	0.799
Female	0	0	9	3	1

Table 3. *Mortality of RAAA patients in COVID period (2020 and 2021).*

Number of RAA patients in COVID period	2020	2021	p-value (Fisher's exact test)
Total	13	15	1
Deceased (30-day mortality)	7	8	

Table 4. *COVID-19 Vaccination and 30-day mortality in 2021. The difference in mortality between COVID-19 vaccinated and non-vaccinated patients was not statistically significant (p=0.3147, Fisher's exact test).*

RAA patients in 2021 subgroup	Vaccinated	Non-vaccinated	Total
Deceased	2	6	8
Survived	4	3	7
Total	6	9	15

Table 5. *Overall mortality and patients' characteristics, comorbidities, seasonal and surgery-related variables (COPD – Chronic Obstructive Pulmonary Disease, PAD – Peripheral Arterial Disease, EVAR – Endovascular Aortic Reconstruction). Fisher's exact test was used for categorical variables, Student's t-test for age and aneurysm diameter, and Mann-Whitney U test for transfused erythrocytes, colloids and plasma). "*" denotes statistically significant p-value.*

Variable	Group	Alive	Deceased	p-value
Congestive heart failure (%)	N	16	23	0.688
	Y	2	5	
COVID (%)	N	5	13	0.234
	Y	13	15	
Chronic renal insufficiency (%)	?	0	1	0.468
	N	6	5	
	Y	12	22	
Stroke (%)	N	16	24	1.000
	Y	2	4	
DEMENTIA (%)	N	18	27	1.000
	Y	0	1	
DIABETES (%)	N	14	25	0.407
	Y	4	3	
SEASON (%)	Autumn	4	7	0.548
	Summer	7	6	
	Spring	4	6	
	Winter	3	9	
YEAR (%)	2018	2	7	0.634
	2019	3	6	
	2020	6	7	
	2021	7	8	
HYPERLIPIDAEMIA (%)	N	16	22	0.453
	Y	2	6	
HYPERTENSION (%)	N	2	3	1.000
	Y	16	25	
COPD (%)	?	0	1	0.662
	N	16	21	
	Y	2	6	
CORONARY ARTERY DISEASE (%)	N	14	22	1.000
	Y	4	6	
PAD (%)	N	18	27	1.000
	Y	0	1	
SMOKING (%)	?	6	8	0.743
	N	8	10	
	Y	4	10	
GENDER (%)	F	6	3	0.124
	M	12	25	
ANEURYSM DIAMETER (mean (SD))		89.06 (14.28)	86.58 (15.90)	0.618
AGE (mean (SD))		74.00 (8.97)	75.46 (8.82)	0.588
TRANSFUSED ERYTHROCYTES (median [range])		1635 [750-2290]	2050 [520-7720]	0.114
TRANSFUSED COLLOIDS (median [range])		1500 [500-2200]	1475 [500-2250]	0.975
TRANSFUSED PLASMA (median [range])		745 [440-1210]	1000 [250-5100]	0.026*
EVAR	N	16	28	0.148
	Y	2	0	

hospital standards of care during and caused by the pandemic *(2,5,11,12)*. This was especially present at the beginning of the pandemic, when people were so afraid of getting infected with the novel virus that they simply did not go anywhere outside the house, not even to the hospital until it was too late. At the time, everything was focused on the pandemic, and other medical emergencies, including RAAAs, suffered from delays in the response of pre-hospital medical services due to the huge volume of critically ill SARS-CoV-2 patients, so that emergency services could not reach everyone *(6,11,12)*. In pre-pandemic time, due to good pre-hospital medical care, many patients with RAA patients were able to come to the hospital, and people were not afraid of going to hospitals as during pandemic. Among them there were lots of those with somewhat worse prognosis and those probably eventually died despite the surgery, thus increasing the 30-day mortality in the pre-pandemic period.

So, from that point of view, although there was an increase in the number of patients with RAAAs during the pandemic, there was a decrease in 30-day mortality, not because of any improvement of in-hospital medical care, but probably because part of most severe RAAA patients simply did not make it to hospital on time *(3)* and the operation was never performed.

Although there was a large difference in 30-day mortality between the pre-pandemic and pandemic patient groups (18.65%), no significant difference was evident between the 2020 and 2021 subgroups (0.51%), which could be explained by the same standard of inpatient medical care for critically ill patients – all procedures were performed by experienced vascular surgeons, and vaccination status and SARS-CoV-2 status did not influence the surgical decision and procedure.

We could not establish any connection between the SARS-CoV-2 pandemic, vaccination and RAAA patients' outcome or vaccination and rupture itself, perhaps due to small numbers – only two of eight patients who died in the 2021 in the early postoperative period were vaccinated (25%). These data suggest that patients with aortic aneurysm who are vaccinated against COVID-19 or who develop or recover from COVID-19 infection do not have a worse prognosis compared to patients in the pre-pandemic period.

Although this study was conducted because we observed an increased number of RAAAs during the pandemic, we did not find a statistically significant difference in the number of RAAAs, nor in 30-day mortality between the pandemic and the pre-pandemic period. There was also no statistically significant difference in mortality between the two subgroups of the pandemic period.

The increase of RAAAs in the pandemic together with the decrease in their 30-day mortality compared to the pre-pandemic period suggests either the reluctance of patients to undergo surgery or the avoidance of regular examinations in hospitals, where lots of patients with SARS-CoV-2 are presumed to be concentrated, and not a change in the quality of the hospital service, because all the procedures were performed according to the same standards. Patients were never directly asked to answer this question, so even if fear of SARS-CoV-2 infection remains the most plausible answer, it should be verified by an independent questionnaire *(13)*.

According to this small, but still evident increase in the number of RAAAs in 2021 compared to 2020 (15 vs. 13), it seems that COVID-19 vaccination did not significantly influence the decision of patients to go for regular examinations or to have aneurysm repair and thereby avoid rupture, but it may be that that trusting the vaccine to be safe *(14)* has led to normalization and improvement of the standard of pre-hospital care to the level of the pre-pandemic period – people (both patients and emergency healthcare professionals) were presumably less frightened of pandemic after the vaccination was found and put to use *(6)*.

The only factor associated with mortality in this study, regardless of pandemic period (amount of transfused fresh frozen plasma), was not consistently found to be significant in other models predicting outcomes in patients with ruptured abdominal aortic aneurysm, while factors associated with mortality in other studies were not shown to be significant in our sample *(15-18)*. This fact might be explained by a small sample in our study, which warrants further investigations by using a larger sample from multiple institutions, as can be found in national or international registries.

CONCLUSION

In this study we found no statistically significant difference in the number of RAAAs, neither in the 30-day mortality of RAA patients between the pandemic and the pre-pandemic period nor between the two subgroups of the pandemic period.

The observed increase in the number of RAAAs in the pandemic with a decrease in their 30-day mortality compared to the pre-pandemic period could be explained by patients avoiding institutions where SARS-CoV2 infections are most likely to be concentrated.

No connection could be established between the pandemic or vaccination and the outcome of RAAA patient or the rupture itself.

LIMITATIONS OF THE STUDY

There are some limitations of this study. First, this is a retrospective study based on data collected from the medical history of patients in a single University hospital cen-

ter, so the number of patients is small. Second, these are the RAAA patients, some of whom have died during or after the surgery. No information was collected on whether the real reason for patients avoiding regular outpatient examinations, if so, was due to a great amount of fear of getting infected with the SARS-CoV-2 virus. Finally, we cannot speculate on patients' reasons for avoiding earlier aneurysm repair – apart from the fear of the actual pandemic and SARS-CoV2 infection, it could also be the patient's decision not to repair the aneurysm due to relatively high known 30-day mortality, or even a failure to recognize a preexisting aneurysm until rupture.

REFERENCES

1. RITCHIE H, MATHIEU E, RODÉS-GUIRAO L, APPEL C, GIATTINO C, ORTIZ-OSPINA E, HASELL J, MACDONALD B, BELTEKIAN D, DATTANI S, ROSER M 2020–2022 "Coronavirus Pandemic (COVID-19)". Our World in Data [Internet]. Available from: https://ourworldindata.org/coronavirus (Last accessed 24 September 2023).
2. LAUKKANEN L, LAHTINEN S, LIISANANTTI J, KAAKINEN T, EHROLA A, RAATINIEMI L 2021 Early impact of the COVID-19 pandemic and social restrictions on ambulance missions. Eur J Publ Health 31(5):1090-5. https://doi.org/10.1093/eurpub/ckab065
3. REPUBLIKA HRVATSKA. MINISTARSTVO UNUTARNJIH POSLOVA. RAVNATELJSTVO CIVILNE ZAŠTITE. "Sve Odluke Stožera civilne zaštite RH za sprečavanje širenja zaraze koronavirusom" [Internet]. Available from: https://civilna-zastita.gov.hr/vijesti/priopcenje-za-medije-stozera-civilne-zastite-republike-hrvatske-od-26-ozujka-u-9-30-sati/sve-odluke-stozera-civilne-zastite-rh-za-sprecavanje-sirenja-zaraze-koronavirusom/2302 (Last accessed 18 May 2024).
4. WILKE M, NEWS24 2022 "How to alleviate your fears of routine medical check-ups and errands during Covid-19" [Internet]. Available from: https://www.health24.com/Medical/Infectious-diseases/Coronavirus/how-to-alleviate-your-fears-of-routine-medical-check-ups-and-errands-during-covid-19-20200623-4 (Last accessed 7 August 2022).
5. YU JH, LIU CY, CHEN WK, YU SH, HUANG FW, YANG MT, CHEN CY, SHIH HM 2021 Impact of the COVID-19 pandemic on emergency medical service response to out-of-hospital cardiac arrests in Taiwan: a retrospective observational study. Emerg Med J 38:679-684. https://doi.org/10.1136/emermed-2020-210409
6. ZHANG J 2021 Hospital Avoidance and Unintended Deaths during the COVID-19 Pandemic. American Journal of Health Economics 7(4). https://doi.org/10.1086/715158
7. FIGL J, HALUZAN D, BRIZIC I, PAVIC P, MESTROVIC T, FIGL S 2020 Increased Number of Major Amputations During Pandemic Could Be Caused by Patients Fear of Sars-Cov-2. Int J Endovasc Treat Innov Tech 1(1):13-5. https://doi.org/10.61797/ijetit.v1i1.39
8. THORNTON J 2020 Covid-19: A&E visits in England fall by 25% in week after lockdown. BMJ 369:1401. https://doi.org/10.1136/bmj.m1401
9. CAO Y, LI Q, CHEN J, GUO X, MIAO C, YANG H, CHEN Z, LI C, LI L 2020 Hospital emergency management plan during the COVID-19 epidemic. Acad Emerg Med 27:309–11. https://doi.org/10.1111/acem.13951
10. R CORE TEAM 2018 R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
11. KALANJ K, MARSHALL R, KAROL K, TILJAK MK AND OREŠKOVIĆ S 2021 The Impact of COVID-19 on Hospital Admissions in Croatia. Front Public Health 9:720948. https://doi.org/10.3389/fpubh.2021.720948
12. SABERIAN P, CONOVALOFF JL, VAHIDI E, HASANI-SHARAMIN P, KOLIVAND PH 2020 How the COVID-19 Epidemic Affected Prehospital Emergency Medical Services in Tehran, Iran. West J Emerg Med 21(6):110-6. https://doi.org/10.5811/westjem.2020.8.48679
13. ROSENBAUM L 2020 The Untold Toll — The Pandemic's Effects on Patients without Covid-19. N Engl J Med 382:2368-71. https://doi.org/10.1056/NEJMms2009984
14. KARLSSON LC, SOVERI A, LEWANDOWSKY S, KARLSSON L, KARLSSON H, NOLVI S, KARUKIVI M, LINDFELT M, ANTFOLK J 2021 Fearing the disease or the vaccine: The case of COVID-19. Pers Indiv Diffe 172:110590. https://doi.org/10.1016/j.paid.2020.110590
15. NEARY WD, CROW P, FOY C, PRYTHERCH D, HEATHER BP, EARNSHAW JJ 2003 Comparison of POSSUM scoring and the Hardman Index in selection of patients for repair of ruptured abdominal aortic aneurysm. Br J Surg 90(4):421–5. https://doi.org/10.1002/bjs.4061
16. KARKOS CD, KARAMANOS D, PAPAZOGLOU KO, KANTAS AS, THEOCHARI EG, KAMPAROUDIS AG, GERASSIMIDIS TS 2008 Usefulness of the Hardman index in predicting outcome after endovascular repair of ruptured abdominal aortic aneurysms. J Vasc Surg 48(4):788–94. https://doi.org/10.1016/j.jvs.2008.05.065
17. TANG T, WALSH SR, PRYTHERCH DR, LEES T, VARTY K, BOYLE JR 2007 VBHOM, a data economic model for predicting the outcome after open abdominal aortic aneurysm surgery. Br J Surg 94(6):717–21. https://doi.org/10.1002/bjs.5808
18. TAMBYRAJA A, MURIE J, CHALMERS R 2007 Predictors of outcome after abdominal aortic aneurysm rupture: Edinburgh Ruptured Aneurysm Score. World J Surg 31(11):2243–7. https://doi.org/10.1007/s00268-007-9181-5