Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

RESEARCH LETTER

COVID-19 and Abdominal Aortic Aneurysm Intervention: When to Defer and When to Operate

Recommendations concerning the management of abdominal aortic aneurysms (AAAs) $\geq$ 5.5 cm during the COVID-19 pandemic from societies, such as the Society for Vascular Surgery and the Vascular Society for Great Britain & Ireland, recommend deferring repair. However, neither document quantifies the optimal deferral time periods, stating that clinicians should consider factors such as COVID-19 transmission risk and rupture risk. The European Society for Vascular Surgery AAA guidelines specify that rapidly growing AAAs ($\geq$ 1 cm/year) should prompt fast track vascular referral;[1] these recommendations were developed and published before the COVID-19 pandemic. McGuinness *et al.* recently reported the results of their risk modelling to address this issue.[2] They include patient, AAA, and COVID-19 risk parameters. This analysis, however, was limited owing to the data on which they based annual rupture risk, which seemed to be an overestimation; and their estimation of peri-operative COVID-19 related mortality, which seemed to be an underestimation.

Annual AAA rupture rates used by McGuinness *et al.* were based on a prospective cohort study of 198 patients turned down for elective repair between 1995 and 2000: 9.4%, 10.2%, and 32.5% for 5.5 – 5.9 cm, 6.0 – 6.9 cm, and $\geq$ 7 cm AAAs respectively.[2] Peri-operative COVID-19 related mortality was assumed to be equivalent to community COVID-19 mortality risk.[2]

More robust pooled data are available on which to base estimates of rupture rates. The meta-analysis by Parkinson *et al.* included 1 514 patients from 11 studies.[3] They reported significantly lower pooled annual rupture rates: 3.5%, 4.1%, and 6.3% for 5.5 – 6 cm, 6.1 – 7 cm, and $>$ 7 cm AAAs respectively. Additionally, there are meta-analysed data available describing post-operative COVID-19 related mortality.[4]

The aim was to conduct risk model analysis using these up to date data, hypothesising that more patient groups would be better served by deferral of repair than McGuinness *et al.* suggest. The model calculates the "optimal strategy" (repair or deferral) at different time-points from when elective repair is considered (3, 6, 9, and 12 months) based on baseline, rupture, operative, and COVID-19 related mortality risks.

Decision tree analysis was performed using data from Parkinson *et al.*[3] to inform annual rupture risk and data from Brown *et al.*[4] to inform peri-operative COVID-19 related mortality. All other model parameters were identical to those used by McGuinness *et al.*[2] Analyses were conducted using the statistical software Amua (version 0.3.0). Baseline annual mortality risk parameters were based on the Center for Disease Control and Prevention's 2016 National Vital Statistics Reports. COVID-19, open and endovascular AAA repair, and AAA rupture related mortality risk estimates were stratified by age.[2,4] Risk of COVID-19 transmission was stratified by community COVID-19 prevalence and in patient/community status, with nosocomial transmission rate estimated as twice community transmission risk.[2]

The results suggest that deferral is preferred to open repair for all AAAs at three months (Fig. 1). Open repair becomes preferable to deferral at six months only in younger patients ($<$ 65 years of age) with aneurysms $>$ 7 cm (when COVID-19 transmission risk is low).

Deferral is preferred to endovascular repair at three months in most scenarios. Endovascular repair becomes preferred to deferral at six months for the majority when COVID-19 transmission risk is low.

This analysis addresses an obvious deficiency in the current guidance by major vascular societies, by accounting for age, repair type, and COVID prevalence. The results support deferral for many patients but highlight that "one size does not fit all", specifying when repair becomes appropriate and for whom.

Evidence on AAA diameter at the time of rupture would suggest that a sizable proportion of ruptures occur in AAAs $>$ 7.0 cm. The IMPROVE trial reported that 78.7% of their cohort had AAA $>$ 7.0 cm.[5] Similarly, Laine *et al.* report that only 8% of ruptured (r)AAAs were below 5.5 cm at the time of rupture.[6] However, such studies do not further inform yearly rupture risk since they only include patients with a rAAA, without a "denominator" (non-rAAA data) available.

This analysis is limited as individual patient comorbidities are not considered, which could significantly influence AAA repair, rupture, and COVID-19 related mortality risks. As such, the results should be used to complement existing mortality risk estimations. Data are based on patients that were turned down for repair: rupture risk may differ for patients considered suitable/fit for repair. The model does not consider relevant factors such as the variability in provision and effectiveness of COVID-19 low "green pathways". However, by providing optimal strategies at differing COVID-19 transmission risk levels, ranging from 0.01% (0.02% nosocomial) to 30% (60% nosocomial), clinicians can interpret the results that most closely align their current local transmission risk. Units with efficient green pathways could use the "0.01%" transmission template as an approximation to their risk. Lastly, the model is not yet validated, and this should be considered when used to support clinical decision making.

These results are a framework for clinicians to time planned intervention for patients with AAAs $\geq$ 5.5 cm. For many patients in areas of low community COVID-19 transmission risk, deferral of repair as suggested by current guidance may increase mortality risk.

McGuinness et al.

EVAR

Infection probability 0.01% (0.02% nosocomial)				Infection probability 1% (2% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6–6.9	7		5.5–5.9	6–6.9	7
50–59				50–59			
60–64				60–64			
65–69				65–69			
70–74				70–74			
75–79				75–79			
80–84				80–84			
≥85				≥85			

Infection probability 10% (20% nosocomial)				Infection probability 30% (60% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6–6.9	7		5.5–5.9	6–6.9	7
50–59				50–59			
60–64				60–64			
65–69				65–69			
70–74				70–74	X	X	
75–79				75–79	X	X	
80–84	X			80–84	X	X	
≥85	X	X		≥85	O	X	

Open repair

Infection probability 0.01% (0.02% nosocomial)				Infection probability 1% (2% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6–6.9	7		5.5–5.9	6–6.9	7
50–59				50–59			
60–64				60–64			
65–69	X	X		65–69	X	X	
70–74	X	X		70–74	X	X	
75–79	Y	O		75–79	Y	O	
80–84	Y	Y		80–84	Y	Y	
≥85				≥85			

Infection probability 10% (20% nosocomial)				Infection probability 30% (60% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6–6.9	7		5.5–5.9	6–6.9	7
50–59				50–59			
60–64				60–64	X	X	
65–69	X	X		65–69	X	X	
70–74	X	X		70–74	O	O	
75–79	Y	Y		75–79	Y	Y	X
80–84			X	80–84			X
≥85			X	≥85			X

Gwilym et al.

EVAR

Infection probability 0.01% (0.02% nosocomial)				Infection probability 1% (2% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6.0–7.0	>7		5.5–5.9	6.0–7.0	>7
50–59				50–59			
60–64				60–64			
65–69	X	X		65–69	X	X	
70–74	X	X		70–74	X	X	
75–79	X	X		75–79	X	X	
80–84	X	X		80–84	X	X	X
≥85	O	O	X	≥85	O	X	X

Infection probability 10% (20% nosocomial)				Infection probability 30% (60% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6.0–7.0	>7		5.5–5.9	6.0–7.0	>7
50–59				50–59	X	X	
60–64				60–64	X	X	
65–69	O	O	X	65–69			O
70–74	O	O	X	70–74			O
75–79	O	O	X	75–79			Y
80–84	Y	O	X	80–84			Y
≥85	Y	Y	O	≥85			

Open repair

Infection probability 0.01% (0.02% nosocomial)				Infection probability 1% (2% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6.0–7.0	>7		5.5–5.9	6.0–7.0	>7
50–59	O	X	X	50–59	O	O	X
60–64	O	X	X	60–64		O	X
65–69	Y	Y	O	65–69		Y	O
70–74	Y	Y	O	70–74		Y	O
75–79				75–79			
80–84				80–84			
≥85				≥85			

Infection probability 10% (20% nosocomial)				Infection probability 30% (60% nosocomial)			
Age	Aneurysm size – cm			Age	Aneurysm size – cm		
	5.5–5.9	6.0–7.0	>7		5.5–5.9	6.0–7.0	>7
50–59			O	50–59			
60–64			O	60–64			
65–69				65–69			
70–74				70–74			
75–79				75–79			
80–84				80–84			
≥85				≥85			

Figure 1. Comparison between an immediate and initial non-operative (delayed) strategy involving endovascular aneurysm repair (EVAR) and open repair for abdominal aortic aneurysm (AAA) at different community COVID-19 infection probabilities. The colour gives the preferred operative (red) or deferral (blue) strategy three months after a decision regarding treatment. The symbols show the preferred strategy for alternate time points of six, nine, and 12 months from consideration of repair: X = change to operative strategy at six months; O = change to operative strategy at nine months; Y = change to operative strategy at 12 months. Results were checked for internal consistency (and adjusted if required) so that the preferred strategy assumed higher operative risk with increasing age in all categories of AAA size.

REFERENCES

1 Wanhainen A, Verzini F, Van Herzeele I, Allaire E, Brown M, Cohnert T, et al. European Society for Vascular Surgery (ESVS) 2019 clinical practice guidelines on the management of abdominal aorto-iliac artery aneurysms. *Eur J Vasc Endovasc Surg* 2019;**57**:8–93.

2 McGuinness B, Troncone M, James LP, Bisch SP, Iyer V. Reassessing the operative threshold for abdominal aortic aneurysm repair in the context of coronavirus disease 2019. *J Vasc Surg* 2020;**72**:E345.

3 Parkinson F, Ferguson S, Lewis P, Williams IM, Twine CP. Rupture rates of untreated large abdominal aortic aneurysms in patients unfit for elective repair. *J Vasc Surg* 2015;**61**:1606–12.

4 Brown WA, Moore EM, Watters DA. Mortality of patients with COVID-19 who undergo an elective or emergency surgical procedure: a systematic review and meta-analysis. *ANZ J Surg* 2021;**91**:33–41.

5 IMPROVE trial investigators. Endovascular or open repair strategy for ruptured abdominal aortic aneurysm: 30 day outcomes from IMPROVE randomised trial. *BMJ* 2014;**348**:f7661.

6 Laine MT, Laukontaus S, Kantonen I, Venermo M. Population-based study of ruptured abdominal aortic aneurysm. *Br J Surg* 2016;**103**:1634–9.

Brenig L. Gwilym[a,*], Frances Kent[a], Christopher P. Twine[b], David C. Bosanquet[a]

[a]Aneurin Bevan University Health Board, UK

[b]Bristol Centre for Surgical Research, Bristol Medical School, University of Bristol, Bristol, England, UK

[*]Corresponding author. Royal Gwent Hospital, Cardiff Road, Newport NP20 2UB, UK.

Email-address: blgwilym@gmail.com (Brenig L. Gwilym)

Available online 4 June 2021

https://doi.org/10.1016/j.ejvs.2021.05.034