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A comparative study looking at trauma and orthopaedic operating efficiency in the COVID-19 era

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ABSTRACT

Backgroud: COVID-19 has led to a reduction in operating efficiency. We aim to identify these inefficiencies and possible solutions as we begin to pursue a move to planned surgical care.

Methods: All trauma and orthopaedic emergency surgery were analysed for May 2019 and May 2020. Timing data was collated to look at the following: anaesthetic preparation time, anaesthetic time, surgical preparation time, surgical time, transfer to recovery time and turnaround time. Data for 2019 was collected retrospectively and data for 2020 was collected prospectively.

Results: A total of 222 patients underwent emergency orthopaedic surgery in May 2019 and 161 in May 2020. A statistically significant increase in all timings was demonstrated in 2020 apart from anaesthetic time which demonstrated a significant decrease. A subgroup analysis for hip fractures demonstrated a similar result. No increase in surgical time was observed in hand and wrist surgery or for debridement and washouts.

Although the decrease in anaesthetic time is difficult to explain, this could be attributed to a reduction in combined anaesthetic techniques and possibly the effect of fear. The other increases in time demonstrated can largely be attributed to the PPE required for aerosol generating procedures and other measures taken to reduce spread of the virus. These procedures currently form a large amount of the orthopaedic case load.

Conclusion: COVID-19 has led to significant reductions in operating room efficiency. This will have significant impact on waiting times. Increasing frequency of regional anaesthesia concurrently with non-aerosol generating surgeries may improve efficiency.

1. Introduction

The COVID-19 pandemic has caused disruption to health care services across the world. The NHS has had to adapt in terms of departmental restructuring, redeployment of staff, service prioritisation and acclimatisation to ever changing PPE guidance.[1]

As operating departments across the UK adapt to new ways of working this will undoubtedly have an effect on operation room (OR) efficiency. At the time of writing this paper, full PPE was recommended for all procedure involving a high speed device. The patients were anesthetised in the OR and not in the anesthetic room. All patients were anesthetised by consultants as trainees and other junior doctors were redeployed to intensive care units and ward-based care of COVID patients. To minimise contamination with settling aerosolised particles, all packed implants and instruments are kept in a clean room outside the OR. After completion of surgery, the patients were extubated and recovered in the OR and not the recovery room.

A careful exploration of OR efficiency will help understand the new time pressures secondary to COVID-19. This is imperative in both planning a response to a possible second surge of COVID-19 cases, or a return to planned surgical care, hopefully in the near future. We hypothesise that due to the stringent restrictions imposed by COVID-19, OR efficiency has reduced. We aim to identify where inefficiencies lie, any contributing factors, and consider how these may be addressed as we scale up operating during a return to planned surgical care.

2. Materials and methods

We analysed all trauma and clinically urgent orthopaedic surgeries performed in Cardiff and Vale University Health Board during May 2019 and May 2020. Institutional review board approval was not required because as per our local trust guidelines, approval is not required for

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service evaluations and we consider this project to be a service evaluation. Informed consent was not applicable as no patient data has been collected for this project. Only OR timings have been collected. STROBE guidelines for observational studies were followed.

Before the pandemic, we had an 8am to 8pm trauma list everyday (3 sessions), dedicated hand trauma lists twice per week (total 5 sessions), dedicated spine trauma list once a week (2 sessions) and 2 additional trauma lists per week (3-4 sessions). During the pandemic due to redeployment of staff members and overall reduced trauma/ urgent orthopaedic cases, we had 2 all day lists from 8am to 8pm. All trauma / urgent cases including hands and spines were done on this list.

Data was collected from the electronic OR data management systems.[2,3] Utilising two OR management systems for data collection allowed cross referencing, ensuring maximal data collection. Specific timings are routinely added as part of standard procedure by the OR team. Data for 2020 was collected prospectively and data from May 2019 collected retrospectively. Specific times collected were: anaesthetic room entry; commencement of anaesthesia; OR entry; operation start (knife to skin); operation end (dressings on); and OR exit. From these timings the following could be calculated:

1 Anaesthetic preparation time (APT): Time from entry to anaesthetic room to commencement of anaesthesia.
2 Anaesthetic time (AT): Time from commencement of anaesthesia to entry into OR.
3 Surgical preparation time (SPT): Time from entry into OR to start of operation.
4 Surgical time (ST): Time from start of operation to end of operation.
5 Transfer to recovery time (TRT): Time from end of operation to exit from OR.
6 Turnaround time (TT): Time from exit from OR to entry of next patient in anaesthetic room.

Data was analysed using SPSS (IBM, version 25). Continuous data was tested for normality using Shapiro-Wilk's test. All timing data differed significantly from a normal distribution and thus non-parametric analyses were performed using the Mann-Whitney U test.

3. Results

A total of 222 patients underwent orthopaedic trauma or urgent surgery during May 2019 and 161 during May 2020. All timing data was non-normally distributed and thus medians and interquartile ranges are described throughout. Overall, more cases were performed in May 2019 compared to May 2020 (Table 1). There was a higher proportion of local anaesthetic cases done in 2020 however this was not statistically significant (Table 2). There was a statistically significant increase in all timings recorded in 2020 except anaesthetic time which showed a significant reduction (Table 3). We performed a sub-group analysis for surgery for neck of femur fractures which also showed similar results (Table 4). A further sub-group analysis of hand and wrist surgery showed that there was no significant increase in surgical time in 2020 (Table 5). A sub-group analysis of debridement and washouts showed the same result (Table 6).

Table 1
Table outlining the types of surgery and anatomical region of surgeries performed in 2019 and 2020.

Type Of Surgery / Anatomical location	2019	2020
Debridement and Washouts	49	23
Elbow	9	4
FFF	55	52
Foot and ankle	19	11
Forearm	5	6
Hand and wrist	37	32
Hip	3	0
Knee	8	9
Nail Bed Repair on finger	9	2
Other hip sugeries	4	2
Polytrauma	3	4
Removal of foerign body	3	0
Removal of infected metalwork	4	4
Revision knee replacememt for infection	1	1
Shoulder	1	4
Spine	5	2
Tibial shaft/plafond fracture fixation	7	5

4. Discussion

COVID-19 has placed an unprecedented pressure on all aspects of the NHS.[4] Although the total number of surgical cases has decreased, there has been a constant demand on operating theatres across all surgical specialities.[5] Significant changes in OR pathways, personal protective equipment (PPE), and altered thresholds for both surgery and general anaesthesia, have led to a relatively unfamiliar OR environment. We have confirmed an increase in total OR time for our urgent orthopaedic and trauma cases compared with a similar cohort in 2019.

The changes introduced for COVID-19 operating relate to our observations. All patients are currently anesthetised in the OR, with the anaesthetic room left empty. APT reflects a short period of time between entering OR and commencing anaesthesia. In 2020, the majority of cases had an APT of 0 minutes. This may reflect a better readiness of the anaesthetic team, often already wearing appropriate PPE, when the patient enters the OR. The observed decrease in anaesthetic time is difficult to explain. The shorter anaesthetic time may reflect a reduced incidence of combined general and regional anaesthetic techniques, information that is not routinely recorded on the OR systems. Addition of regional anaesthesia to general anaesthesia is good for post-operative pain relief but this adds to the time that is spent by the patient in close proximity to the anaesthetist. This may be one of the reasons why a combined anaesthetic was avoided. Fear can be a potent motivator and it is also possible that the fear of aerosol generation during intubation may decrease the time taken to perform the procedure.[6] All anaesthetics in 2020 have been performed solely by a consultant anaesthetist as registrars and other junior doctors were redeployed to COVID zones. This was not true in 2019, when trauma lists were routinely staffed either by a senior registrar grade, or a more junior registrar with consultant supervision. Thus, the reduced anaesthetic time observed overall may reflect a reduction in anaesthetics performed as part of training. We hypothesise that an overall reduction in anaesthetic time appears to be due to a combination of the above factors.

The increase in SPT likely represents the time necessary to don full PPE. We have improved efficiency in this regard with the surgical team donning during anaesthesia. As soon as anaesthesia is complete the scrub staff commence opening instrument trays. Prior to COVID-19 these stages were routinely performed during anaesthesia. SPT could be reduced by opening instrument trays prior to the commencement of anaesthesia. The trays would need to be covered with a sterile drape during this time and the scrub team would be required to vacate OR. However, this would increase cost by using extra drapes, surgical gowns and gloves.

ST increased for most surgeries. During the study time frame, any orthopaedic procedure utilising a high-speed device, either a drill, burr or saw, was considered an aerosol generating procedure (AGP). AGPs

Table 2
Table showing distribution of anaesthetic used in 2019 and 2020.

	2019	2020	
General Anaesthetic +- Regional	178 (80.18 %)	131 (81.36 %)	x2 (2) = 5.952, p =.051
LA	10 (4.50 %)	15 (9.32 %)	
Regional	34 (15.32 %)	15 (9.32 %)	

Table 3
Table showing distribution of theatre timings recorded for all cases combined in 2019 and 2020.

	2019 (N = 201)		2020 (N = 133)		P
	Median T (IQR)	Mean T (95% CI for mean)	Median T (IQR)	Mean T (95% CI for mean)	
Anaesthetic Preparation time	1 (1 - 3)	3.13 (1.61 – 4.66)	0 (0 - 3.5)	1.07 (0.34 – 1.80)	0.000
Anaesthetic time	20 (12.75 - 29)	22.10 (19.69 – 24.52)	2 (2 - 12.5)	8.91 (5.37 – 12.45)	0.000
Surgical preparation time	12.5 (8 - 18)	14.51 (13.17 – 15.84)	21 (9 - 47)	26.78 (20.34 – 33.23)	0.000
Surgical time	45 (22 - 71)	54.40 (47.44 – 61.36)	56 (35 - 86.5)	61.75 (48.73 – 74.76)	0.025
Transfer to recovery time	7 (4 - 13)	(9.64 (8.32 – 10.96))	18 (6.5 - 35)	24.76 (17.42 – 32.11)	0.000
Turnaround time	16 (5 - 38.75)	31.77 (23.02 – 40.52)	48 (18 - 74)	57.42 (42.00 – 72.83)	0.000

N: Number Of Cases; T: Time in Minutes, IQR: Interquartile Range, CI: Confidence Interval.

Table 4
Table showing distribution of theatre timings recorded for surgeries for fracture neck of femur.

	2019 (N = 44)		2020 (N= 46)		P
	Median T (IQR)	Mean T (95% CI for mean)	Median T (IQR)	Mean T (95% CI for mean)	
Anaesthetic Preparation time	1 (1 - 3)	2.71 (.91 – 4.51)	0 (0 - 4.25)	1.65 (0.34 – 2.96)	0.011
Anaesthetic time	28.5 (22.5 - 39.5)	29.87 (25.29 – 34.45)	5 (0 - 30)	11.88 (4.02 – 19.74)	0
Surgical preparation time	18 (15 - 23)	19.87 (17.34 – 22.40)	45.5 (18.75 - 59.25)	48.94 (38.66 – 59.22)	0
Surgical time	53 (39.25 - 67.5)	56.97 (48.31 – 65.62)	70.5 (43 - 87.5)	72.88 (60.25 – 85.52)	0.025
Transfer to recovery time	7 (4 - 10.75)	8.90 (6.17 – 11.63)	18.5 (10 - 35)	23.06 (15.80 – 30.32)	0
Turnaround time	13 (6 - 29)	26.06 (13.61 – 38.52)	56 (31.5 - 80)	73.24 (38.36 – 108.11)	0

N: Number Of Cases; T: Time in Minutes, IQR: Interquartile Range, CI: Confidence Interval.

require all staff in OR to wear full PPE, including a water-resistant gown, gloves, an FFP3 mask and eye protection (visor or goggles). Healthcare workers find PPE very uncomfortable and this can lead to decreased efficiency.[7] Fear of aerosolising the contagion whilst using a high-speed device may also contribute to an increase in operating timing. Furthermore, the FFP3 masks hinder communication between the surgeon and all other members of the team. For most orthopaedic cases, individually packed sterile implants and screws are used. To minimise contamination with settling aerosolised particles, all implants and instruments are kept in a clean room outside the OR. Thus, any request for implants or additional instruments is relayed through a number of staff, all impaired by PPE to the "clean" runner outside the OR. The implant is then delivered through the same pathway in reverse. Subgroup analysis showed that the ST did not increase significantly for hand and wrist procedures and washouts. Implants for most hand and wrist operations

Table 5
Table showing distribution of theatre timings recorded for surgeries on Hand and Wrist.

	2019 (N = 46)		2020 (N = 27)		P
	Median T (IQR)	Mean T (95% CI for mean)	Median T (IQR)	Mean T (95% CI for mean)	
Anaesthetic Preparation time	2 (1 - 3)	2.47 (1.68 – 3.26)	0 (0 - 2)	0.41 (0 – 1.07)	0.001
Anaesthetic time	13 (7.75 - 19)	15 (12.13 – 17.87)	1 (0 - 9)	4.88 (1.5 – 8.26)	0
Surgical preparation time	9 (5.75 - 11.5)	9.53 (7.36 – 11.71)	8 (5 - 15)	11.94 (4.74 – 19.15)	0.85
Surgical time	29 (15.75 - 55.75)	38.16 (28.01 – 48.30)	40 (24 - 66)	43.29 (27.52 – 59.07)	0.13
Transfer to recovery time	5 (3 - 9)	6.72 (4.76 – 8.68)	10 (5 - 19)	12.82 (2.68 – 22.97)	0.024
Turnaround time	8.5 (3 - 39)	37.16 (10.54 – 63.77)	18 (9.5 - 58.5)	35.88 (14.43 – 57.33)	0.128

N: Number Of Cases; T: Time in Minutes, IQR: Interquartile Range, CI: Confidence Interval.

Table 6
Table showing distribution of theatre timings recorded for debridement and washout surgeries.

	2019 (N = 46)		2020 (N = 27)		P
	Median T (IQR)	Mean T (95 % CI for mean)	Median T (IQR)	Mean T (95 % CI for mean)	
Anaesthetic Preparation time	1 (1 - 2)	1.92 (1.03 – 2.81)	0 (0 - 5)	.41 (0 – 1.07)	0.986
Anaesthetic time	20.5 (12 - 27)	21.04 (15.83 – 26.25)	1 (0 - 7.5)	4.88 (1.5 – 8.26)	0
Surgical preparation time	11 (6 - 13)	11.54 (9.07 – 14.02)	22 (5 - 32)	11.94 (4.74 – 19.15)	0.036
Surgical time	23 (16 - 37.75)	29.79 (20.86 – 38.72)	26 (17 - 44.5)	33.29 (17.52 – 49.07)	0.477
Transfer to recovery time	6.5 (3 - 11)	8.21 (5.45 – 10.96)	8 (2 - 26)	12.82 (2.68 – 22.97)	0.402
Turnaround time	22 (14 - 38)	30.75 (12.49 – 49.01)	27 (10 - 40)	35.88 (14.43 – 57.33)	1

N: Number Of Cases; T: Time in Minutes, IQR: Interquartile Range, CI: Confidence Interval.

are sterilised on the instrument trays, negating the need for the "PPE relay". Similar logic applies to washouts where no implants are required.

Guidance around standard procedures change regularly as the COVID-19 pandemic continues to develop. Initially, following any AGP, the patient was not moved from the OR for 20 minutes,[8] leading to an increase in TRT. The OR is then cleaned using a chlorine-based solution that is left to work for 20 minutes. A subsequent clean is then completed before the OR is ready to use. These measures that were introduced to minimise viral spread significantly add to the TT.

Procedures performed under local anaesthesia or those that did not generate aerosol did not require additional cleaning steps. There was no significant increase in TRT and TT for procedures such as washouts or non-AGP procedures performed under local anaesthesia. New guidance for planned surgery, including AGPs, allow patients to immediately vacate the OR once surgery is complete.[9] This will likely reduce the TRT and TT.

The observed reduction in OR efficiency will have major implications when planned surgery is reintroduced. It would be commonplace for a normal all-day elective list in 2019 to include four primary major joint arthroplasties. Given the current changes in pathways and observed timings, a realistic projection would be the completion of 2-3 major joint arthroplasties. This would equate to a 25-50 % drop in throughput. It is essential that this is considered in planning future surgical lists. This will be an added burden on the overall waiting lists for planned surgery, an already significant worry for many patients.[10] The NHS and UK government may need to consider providing additional operating capacity to cope with the increase in waiting lists. This will have a significant impact on NHS expenditure.

Continuing changes to national guidance suggests that only the use of high-speed devices on the respiratory tract are considered AGP.[1] This is contradictory to other evidence that exists in the literature regarding aerosol production and the use of high-speed devices.[11–13] Currently, we have chosen to continue using full PPE for orthopaedic procedures involving use of high-speed devices, accepting the reduced efficiency in order to maintain patient and staff safety.

We acknowledge the limitations of our study. Data for 2019 was collected retrospectively. There are inconsistencies and missing data for both years, but there is no reason to think that these inconsistencies changed between 2019 and 2020. Also, the 2 cohorts are not directly comparable as the surgeries were performed in physically different operating rooms in 2019 and 2020 with different surgical staff. The mindset of surgeons, anaesthetists and other members of staff throughout the hospital were also different in 2020 compared to 2019.

5. Conclusion

Changes implemented during COVID-19 have led to a significant reduction in the efficiency of ORs. This will have significant effect on increased waiting times for elective surgery. Increasing frequency of regional anaesthesia concurrently with safe non-aerosol generating surgeries may improve operating room efficiency however, further research is needed to prove this.

CRediT authorship contribution statement

Scott Thomas Mercer: Conceptualization, Data curation, Writing - original draft, Writing - review & editing. **Rishi Agarwal:** Conceptualization, Writing - original draft, Writing - review & editing. **Kathryn Sian Satya Dayananda:** Conceptualization, Writing - review & editing. **Tariq Yasin:** Conceptualization, Writing - review & editing. **Ryan W Trickett:** Supervision, Project administration, Conceptualization, Formal analysis, Writing - review & editing.

Declaration of Competing Interest

None.

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