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St Andrew's COVID-19 surgery safety (StACS) study: The Burns Centre experience

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ABSTRACT

Background: The COVID-19 pandemic caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has the potential to significantly impact burns patients both directly through infective complications of an immunocompromised cohort, and indirectly through disruption of care pathways and resource limitations. The pandemic presents new challenges that must be overcome to maintain patient safety; in particular, the potential increased risks of surgical intervention, anaesthesia and ventilation. This study comprehensively reviews the measures implemented to adapt referral pathways and mitigate the risk posed by COVID-19 during the height of the pandemic, within a large Burns Centre.

Methods: A prospective cohort study was designed to assess patients treated at the Burns Centre during the UK COVID-19 pandemic peak (April–May 2020), following implementation of new safety measures. All patients were analysed for 30-day mortality. In addition, a prospective controlled cohort study was undertaken on all inpatients and a random sample of outpatients with telephone follow-up at 30 days. These patients were divided into three groups (operative inpatients, non-operative inpatients, outpatients). COVID-19 related data collected included test results, contact with proven cases, isolation status and symptoms. The implemented departmental service COVID-19 safety adaptations are described.

Results: Of 323 patients treated at the Burns Centre during the study period, no 30-day COVID-19 related deaths occurred (0/323). Of the 80 patients analysed in the prospective controlled cohort section of the study, 51 underwent COVID-19 testing, 3.9% (2/51) were positive. Both cases were in the operative group, however in comparison to the non-operative and outpatient groups, there was no significant increase in COVID-19 incidence in operative patients.

Conclusions: We found no COVID-19 related mortality during the study period. With appropriate precautions, burns patients were not exposed to an increased COVID-19 risk. Similarly, burns patients undergoing operative management were not at a significantly increased risk of contracting COVID-19 in comparison to non-operative groups.

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1. Background

The COVID-19 pandemic has become an acute challenge for burn care globally. Initial studies on The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus reported a high incidence of Acute Respiratory Distress Syndrome (ARDS) in hospitalised and co-morbid patients [1–4]. As such, the virus has the potential to significantly impact patients with burn injuries, especially those requiring operative or intensive care support. The elderly population, who are disproportionately affected by burn injuries in the UK [5,6], have also been found to be at an increased risk of death due to COVID-19 [7,8]. These facts emphasise the need to have a full risk assessment of the impact on COVID-19 on the delivery of burn care.

This study seeks to address the current void in our understanding of the safety of delivering burn care during this pandemic. By reviewing and reporting on our own service during the peak of the UK pandemic (Spring 2020) we aim to give an insight into our adaptations alongside COVID-19 incidence data and COVID-19 related deaths data within our centre.

At an early stage during the pandemic, patients undergoing surgical procedures were suspected to be at an increased risk of contracting coronavirus due to the inherent physiological stresses of surgery, the use of invasive airway equipment, ventilator support, and close contact with multiple members of staff. The British Association of Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS) in conjunction with the British Burns Association (BBA) drew up national guidelines relating to surgical burn care [9]. An international multicentre cohort study consisting of 1128 emergency (74.0%) and elective (24.8%) surgical patients showed COVID-19 to be present in 26.1% pre-operatively, and this was associated with a 30-day mortality of 21.1% [10]. With this in mind, this study also specifically compares COVID-19 incidence between surgical and non-surgical patients within our burn centre.

Our Centre manages inpatient and outpatient burn injuries of all types and severity, serving a population of 9.8 million across the East of England and Greater London, an area which became the epicentre of the UK coronavirus outbreak. Following consultation nationally, and recognising the increased burden on critical care facilities within the London area, our unit was designated as a potential national centre for burn care. It therefore became necessary, as the main centre delivering burn care during this period in the London and South East region, to evaluate the risk of contracting coronavirus whilst receiving various types of surgical care in our burn service, to guide future treatments and healthcare strategy. Whilst some units have described their strategies to help deliver a safe service [11,12], few have provided data to support these changes.

The St Andrew's Centre for Burns is one of the largest of its kind in Europe. In 2019 we received 1959 new referrals and performed 514 acute operations for patients, including both adult and paediatric patients. The Burns Centre is self-contained with a dedicated intensive care unit (ICU), admission/resuscitation room, operating theatre and multi-disciplinary team (MDT) conference facility.

Significant service adaptations were implemented immediately after the UK government announced a stay at home order at the end of March 2020, taking into account nationwide guidance [13]. Treatment priorities were quickly established [14] alongside BAPRAS-approved public education via social media [15], in an attempt to reduce the strain on hospital resources.

2. St Andrew's Burns Centre COVID-19 service response

2.1. *Department layout and general service adaptations*

The Burns Centre is a purpose-designed facility delivering adult and paediatric inpatient, outpatient and outreach care. It comprises of a purpose-built, burn-specific ICU with 8 beds, suitable for adult and paediatric patients, 8 adult rehabilitation/ward-level beds (4 side-rooms and a 4-bed bay), resuscitation room and dedicated burns operating theatre (with anaesthetic and recovery rooms). These areas are self-contained. The outpatient department and paediatric burns ward (4 side-rooms and a 4-bed bay) are within the same building, but separate to the main centre. As such, these patient groups have little to no interaction with each other. If a team member was required to enter a clinical area, a formal sign-in/out was required to record and track potential transmission. Akin to protocols in other NHS hospitals, symptomatic team members or close contacts of known cases were required to test and self-isolate for 14 days. Multidisciplinary team (MDT) meetings took place in large rooms with adequate distancing and was restricted to core members, with other team members taking part via video-link. The overall approach to burn care during the COVID-19 pandemic, involved a focus on the prioritisation of patient requirements and pathways such as cancelling non-urgent elective surgery; these are further described below.

2.2. *Operating theatre*

To better manage the risks of potential aerosol generating procedures, including intubation, bronchoscopy and initial wound care, the admission/resuscitation room was no longer utilised for urgent debridement, assessment or emergency procedures such as escharotomy/fasciotomy. All burns requiring urgent debridement or surgical intervention were instead directed straight to the burns operating theatre which has a specific High Efficiency Particulate Absorbance (HEPA) filtration system to better control potential aerosols during patient management. All burns admissions were treated on a 'COVID-19 positive until proven otherwise' basis. Theatre staff were required to wear full personal protective equipment (PPE) for high risk or potential aerosol generating procedures including anaesthesia-related aerosol during intubation, bronchoscopy or general anaesthesia, and surgical causes of aerosol including use of versajet or use of an electric dermatome. The PPE required included the use of a gown, double gloves, filtering face piece level 3 (FFP3) mask and face visor. Donning and doffing instructions were clearly on display in the appropriate zones and specific staff education and

training was delivered alongside mask fit-testing to ensure effective PPE use. Patients were anaesthetised and recovered in theatre (or on ICU if an ICU patient), theatre recovery was therefore converted into the 'doffing zone'. Donning took place in the scrub bay, over 2 m away from the operating table. As the turnaround time for COVID-19 swab results improved over the course of the study period, it became a requirement for non-emergency burn cases to have a COVID-19 test result before induction; this was deemed valid if taken within 72 h prior, and the patient had been adhering to self-isolation instructions in that time period.

2.3. *Intensive care*

Each ICU room is equipped with a separate gowning room and a 'hopper' or chute to transfer dirty linen or waste away from the room itself. In response to COVID-19, this system was reversed. Instead, clean materials were transferred into the room via the 'hopper' and the gowning room was instead used as the 'doffing zone' and disposal route. All staff within the main ICU room wore full protection with exhale mask filters, even when managing patients who had negative swabs, in order to prevent disease transmission from staff to critically ill patients. Full protection was also indicated to reduce risk of exposure to staff from ventilated patients, in case of an accidental break in the ventilator circuit.

Given the strain on national ICU capacity during the peak of the outbreak, consideration was given to the use of our ICU beds, given their burn-specific capabilities. It was agreed by NHS England that our centre would therefore act as the national hub for ICU-level burn care in adults. It was thus agreed that these bed spaces would be exempt from taking any non-burn COVID-19 patients and that the staffing levels would be protected where possible. This required provisions to be put in place for mutual staffing aid from other burns providers within the UK burns network.

2.4. *Ward care*

It was mandatory for all team members to wear surgical scrubs, a surgical facemask, single-use gloves and gown with all patient interactions. A COVID-19 swab was taken from all inpatients at the point of admission either from the throat or the nasopharynx if an ICU patient. A temperature check and symptom screening questionnaire were also completed. If the patient remained in the centre for 5 days or more, a repeat COVID-19 swab was taken. This was to mitigate the risk of an initial false-negative result or inadvertent hospital-acquired transmission of COVID-19. Visiting was restricted to one family member only.

2.5. *Outpatient department*

All patients who arrived at the outpatient department underwent symptom screening and a temperature check. Outpatients were not routinely swabbed if asymptomatic. Patients were not permitted to bring family or friends, unless in extenuating circumstances. They were then assessed by staff wearing a surgical facemask, single-use gloves and apron. A one-way system was implemented through the department to improve patient flow and to reduce interaction.

Follow-up arrangements for burns patients was made on a case-by-case basis using a combination of video clinics, and, with agreement, use of the dressings clinic and clinical expertise of plastic surgery units within our catchment area that would normally offer only a limited burns service. Given the accessibility and availability of high-quality cameras built into smart phones, suitable patients were encouraged to send photographic updates of their burn wounds to the outpatient nurses on a dedicated, secure nhs.net email account, in accordance with NHS England and Royal College of Surgeons guidance [16]; this helped to reduce the number of face-to-face appointments. We are yet to receive a complaint or experience an adverse outcome associated with this system of wound follow-up. With the reduction in outpatient attendances, the satellite outreach clinic was able to be discontinued, reducing unnecessary travel and potential virus exposure risk.

This study provides an in-depth overview of the activity and outcomes at a major Burns Centre service following safety adaptations implemented specifically to mitigate COVID-19 risk during the UK pandemic peak (April–May 2020). Thirty-day mortality outcomes are prospectively evaluated within a cohort study design for all patients, with further focus on the risk of operative management within a prospective controlled cohort study design.

3. Methods

A prospective cohort study was designed to assess all adult and paediatric patients treated at the Burns Centre during the UK COVID-19 pandemic peak (April-May 2020). Clinical governance board approval was granted (CA20-012). Thirty-day mortality data for all patients was collected via the electronic database that updates in line with local and national registration information (Lorenzo, DXC Technology).

In addition, efforts were made to contact all inpatients and a random sample of outpatients to be included within a prospective controlled cohort study design; these patients were followed-up by telephone at 30 days post first operation (or 30 days post first assessment if non-operative). Contactable patients were divided into three patient subgroups and a comparative analysis was subsequently undertaken: those who were inpatients and had surgery (operative inpatient group) or non-operative management (non-operative inpatient group), and those who were managed purely on an outpatient basis (outpatient group). Patients were divided into these groups because comparing the surgical group to an outpatient group alone would not address the obvious potential confounder of hospital exposure. The increased risk of contracting COVID-19 in hospital has been suggested [17]. Similarly, investigating differences between hospital inpatients and outpatients can give insight into effectiveness of in-hospital service adaptations.

Regarding the prospective controlled cohort part of this study, demographic and injury specific data were collected at the point of presentation. Results of COVID-19 tests performed locally were collected as soon as they became available. 10-point patient service satisfaction, BMI, smoking status, clinic

attendance, contact with confirmed COVID-19 cases, isolation status, COVID-19 related symptoms and COVID-19 hospital treatment were recorded via review of patient records and telephone follow-up.

Data were analysed with SPSS [18], using the analysis tests as indicated (Tables 1 & 2).

4. Results

There were 323 patients (77 inpatients, 246 outpatients) reviewed and treated at the St Andrew's Burns Centre over the prospective cohort study period (April–May 2020). There were no 30-day COVID-19 related deaths during this period (0/323). Compared to the same period last year, referrals increased from 304 to 323 (+6.2%), however operations decreased from 81 to 61 (−24.7%) (Fig. 1) and occupied bed days decreased from 808 to 586 (−27.5%). The 61 operations in the study period were performed on 51 patients. 8 patients were admitted to ICU and required resuscitation for their burn injuries. Of these ICU patients, 3 were diagnosed with inhalational injury. Admissions included 37 paediatric patients and 40 adult patients. Across the cohort of 323 patients, size of burn injuries ranged from <1% to 83%.

In total, 127 patients were identified for follow up; this included all inpatients (paediatric and adult) and a random sample of 50 outpatients from the total 246 seen. Eighty patients (63%, 80/127) who responded to telephone follow-up at 30 days were included in the prospective controlled cohort study group (Fig. 2). Response rates in each group are as follows: operative inpatient group 76.4% (39/51), non-operative inpatient group 61.5% (16/26) and outpatient group 50.0% (25/50). Demographic data for these patients are presented in Table 1. There were 31 female and 49 male patients followed-up within the study, of whom 33 were paediatric and 47 were adult patients (average age of 23.5 (SD 27.5)).

Table 1 – Controlled cohort study patient demographics, appointments, service satisfaction and treatment outcome.

Variables	Operative inpatients (n = 39)	Non-operative inpatients (n = 16)	Outpatients (n = 25)	Test statistic	df	p
Sex, n (%)						
Female	11 (28.2)	10 (62.5)	10 (40)	5.646	2	0.059^{CS}
Male	28 (71.8)	6 (37.5)	15 (60)			
Age in years, median (IQR)	32 (5–56)*	1 (1–5.8)*,2*	28 (21–59)2*	15.436	2	**<0.001^{KW}**
Ethnicity, n (%)						
White	27 (69.2)	8 (50)	21 (84)	7.865	–	0.081^{F}
Black	6 (15.4)	6 (37.5)	1 (4)			
Asian	6 (15.4)	2 (12.5)	3 (12)			
BMI, median (IQR)	24 (20–30)*	15 (12–18)*,2*	23.3 (20.6–27.2)2*	17.456	2	**<0.001^{KW}**
Comorbidities present, n (%)	16 (41)	2 (12.5)	11 (44)	4.940	2	0.085^{CS}
Number of comorbidities, median (IQR)	0 (0–1)	0 (0 – 0)	0 (0–1.5)	4.445	2	0.108^{KW}
Smoker, n (%)	8 (20.5)	2 (12.5)	7 (28)	1.425	2	0.480^{CS}
Total burn surface area percentage, median (IQR)	4 (1–12)*	5.5 (4.3–7.8)2*	1 (0.5–2.8)*,2*	26.241	2	**<0.001^{KW}**
Burn type, n (%)				16.036	–	**<0.05^{F}**
Flame	17 (43.6)	2 (12.5)	5 (20)			
Scald	16 (41)*	14 (87.5)*	13 (52)			
Contact	2 (5.1)	0 (0)	4 (16)			
Chemical	2 (5.1)	0 (0)	3 (12)			
Radiation	1 (2.6)	0 (0)	0 (0)			
Medical	1 (2.6)	0 (0)	0 (0)			
Anaesthetic modality, n (%)						
GA	35 (89.7)	NA	NA	–	–	–
RA	4 (10.3)	NA	NA			
Number of operations, median (IQR)	1 (0)	NA	NA	–	–	–
Length of Stay, median (IQR)	5 (4–14)	3 (3–4)	NA	−2.862	–	**<0.05^{MW}**
Hospital post-operative/1st assessment appointments, median (IQR)						
BDC	3(2–5)	3 (1.3–3)	3 (2–4)	2.180	2	0.336^{KW}
OPD	0 (0 – 0)	0 (0 – 0)*	0 (0–2)*	6.840	2	**<0.05^{KW}**
Remote post-operative/1st assessment appointments, median (IQR)						
BDC	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	1.736	2	0.420^{KW}
OPD	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0.000	2	0.999^{KW}
Service satisfaction score (/10), median (IQR)	10 (9–10)	10 (10 – 10)	10 (10 – 10)	4.406	2	0.110^{KW}
Treatment outcome rating (/10), median (IQR)	10 (9–10)*,2*	10 (10 – 10)*	10 (10 – 10)2*	11.745	2	**<0.05^{KW}**

SD = standard deviation; IQR = interquartile range; LA = local anaesthetic; RA = regional anaesthetic; GA = general anaesthetic; BDC = burns surgery dressing clinic; OPD = doctor outpatient department consultation. *, 2* indicate statistical significance $p < 0.05$ using post-hoc test after Bonferroni correction between groups with identical symbol. ¥ absolute value as only 1 patient in the analysis; KW: Kruskal Wallis H test; CS: chi-square test; F: Fisher test; MW: Mann Whitney U test.

Table 2 – COVID-19 related data.

Variables	Operative inpatients (n = 39)	Non-operative inpatients (n = 16)	Outpatients (n = 25)	Test statistic	df	p
Pre-operative/1st assessment positive contact, n (%)	0 (0)	1 (6.3)	2 (8)	3.375	–	0.185[F]
How many days, median (IQR)	–	16[¥]	22 (-)	–	–	–
Pre-operative/1st assessment isolation, n (%)	4 (10.3)	1 (6.3)	3 (12)	0.386	–	0.999[F]
How many days, median (IQR)	31 (-)	14[¥]	90 (-)	1.852	2	0.396[KW]
Pre-operative/1st assessment symptoms, n (%)	2 (5.1)	0 (0)	1 (4)	0.674	–	0.999[F]
How many days, median (IQR)	18.5 (-)	–	20[¥]	–	–	–
Symptom duration (days), median (IQR)	8 (-)	–	7[¥]	–	–	–
Temperature, n (%)	1 (50.0)	–	1 (100)	–	–	0.999[F]
Chills, n (%)	0 (0)	–	1 (100)	–	–	0.333[F]
Cough, n (%)	1 (50.0)	–	1 (100)	–	–	0.999[F]
SOB, n (%)	0 (0)	–	1 (100)	–	–	0.333[F]
Body aches, n (%)	0 (0)	–	1 (100)	–	–	0.333[F]
Nausea/vomit, n (%)	0 (0)	–	1 (100)	–	–	0.333[F]
Diarrhoea, n (%)	0 (0)	–	1 (100)	–	–	0.333[F]
Rhinorrhoea, n (%)	1 (50.0)	–	0 (0)	–	–	0.999[F]
Post-operative/1st assessment positive contact, n (%)	0 (0)	0 (0)	0 (0)	–	–	–
Post-operative/1st assessment isolation, n (%)	3 (7.7)*	6 (37.5)*	2 (8)	7.651	–	**<0.05**[F]
How many days, median (IQR)	14 (-)	8.5 (6–15.8)	18.5 (-)	1.035	2	0.596[KW]
Post-operative/1st assessment symptoms, n (%)	0 (0)	1 (6.3)	0 (0)	3.059	–	0.196[F]
How many days, median (IQR)	–	2[¥]	–	–	–	–
Symptom duration (days), median (IQR)	–	2[¥]	–	–	–	–
Temperature, n (%)	–	1 (100)	–	–	–	–
Test performed, n (%)	34 (87.2)*	14 (87.5)[2*]	3 (12)*,[2*]	42.141	2	**<0.001**[CS]
Positive test, n (%)	2 (5.9)	0 (0)	0 (0)	1.191	–	0.999[F]
Hospital admission due to COVID, n (%)	0 (0)	0 (0)	0 (0)	–	–	–
Mortality at 30 days, n (%)	0 (0)	0 (0)	0 (0)	–	–	–

IQR = interquartile range; SOB = shortness of breath. *, 2* indicate statistical significance $p < 0.05$ using post-hoc test after Bonferroni correction between groups with identical symbol. ¥ absolute value as only 1 patient in the analysis; KW: Kruskal Wallis H test; CS: chi-square test; F: Fisher test; MW: Mann Whitney U test.

The majority of burns were scald injuries (53.8%) (Table 1). The median TBSA in the study follow up cohort was 3% (range 0.5–70.0%). Regarding recognised risk factors, 58.8% (47/80) were male, 30.0% (24/80) were of BME ethnicity, 21.3% (17/80) were smokers and 36.3% (29/80) had one or more co-morbidities. 16.2% (13/80) were obese according to body mass index (BMI). The median patient service satisfaction score was 10/10 (IQR 10–10), and treatment satisfaction score was 10/10 (IQR 10–10).

COVID-19 related data for each patient group, including contact, isolation status, symptoms, test results and 30-day mortality data are presented in Table 2. Of the contactable patients, COVID-19 test results were available for 34 operative inpatients, 14 non-operative inpatients and 3 outpatients (total n = 51) (Fig. 2). Of the patients who had COVID-19 test results available, 3.9% (2/51) were positive. One patient in the non-operative inpatient group developed potential COVID-19 related symptoms after first assessment (pyrexia).

5. Discussion

It is important to note that at the beginning of the study period, the centre was treating a COVID-19 positive patient following major burns. They did not meet the inclusion criteria as they were admitted prior to the study period.. This patient was also managed in line with our stated COVID-19 protocols, had an uncomplicated recovery and survived. This patient was of BME ethnicity and had a BMI of >30. There were no other known positive inpatients or outpatients at the start of the study.

In the prospective study of patients admitted to our Burns Centre during the UK pandemic peak, there were no 30-day COVID-19 related deaths following burn injury (0%, 0/323). Patients treated at the Burns Centre during this period were not found to have an increased incidence of death from COVID-19.

In the prospective controlled cohort part of the study, 3.9% (2/51) of patients tested were COVID-19 positive. At the

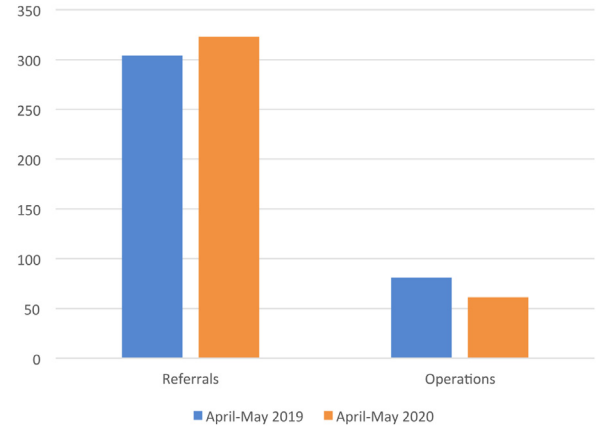

Fig. 1 – St Andrew's Burns Centre activity over the study period in comparison to the same time frame in the previous year. 323 referrals were received and 61 operations were performed during the UK COVID-19 pandemic peak (April–May 2020); This represented an increase in referrals by 6.2% and a decrease in operations by 24.7% compared to the previous year (April–May 2019).

beginning of the study period, 2.1 million people (3.19% of the population) were estimated to have symptomatic COVID-19 in the UK [19]. Patients treated at the Burns Centre during this period were not found to have an increased prevalence of COVID-19 positivity compared with the general population during the study period.

The three patient groups followed-up within the prospective controlled cohort study were well matched for sex, ethnicity, presence of co-morbidity and smoking status, however there was heterogeneity in age, BMI, TBSA and burn type (Table 1); furthermore the 3 groups were well matched for pre-operative/first assessment isolation, COVID-19 contact and symptom development (Table 2). The significant differences in age, BMI and injury mechanism can be explained by the larger number of paediatric patients who were admitted, but treated non-operatively; as with other studies, we found that paediatric patients were more commonly affected by scald injuries [20]. The operative and outpatient groups were better matched with regards to age and BMI; thus, the outpatient cohort could be considered a more useful control/comparator group for operative inpatients.

Only 5.9% (2/34) of tested operative inpatients were COVID-19 positive following their procedure; this proportion was not significantly higher than either the non-operative inpatient (0%, 0/14) or outpatient (0%, 0/3) groups. Outpatients were not routinely tested during this period, in line with public health guidelines [13], resulting in a smaller proportion having tests (Table 2). No patients came into contact with a COVID-19 positive person less than 14 days prior to their admission. There were no differences between the three groups with respect to post-operative/first assessment symptom development, with only one paediatric patient in the non-operative inpatient group reporting symptoms (Table 2). When considered together, these findings highlight that there was no increased COVID-19 related risk to patients, regardless of their treatment group, and that the implemented service safety adaptations were sufficient.

In terms of the aforementioned single report of symptom development after contact with the Burns Centre, this paediatric patient sustained a 7% TBSA scald injury and was managed non-operatively requiring a two-day admission. The parents reported a raised body temperature 2 days post-discharge which settled after a further 2 days. The patient tested negative for COVID-19. Of the two patients who tested positive for COVID-19 on throat swab, one was an asymptomatic paediatric case from a routine admission swab from the very beginning of the study period, the other was an asymptomatic adult operative patient who tested positive 5 days post-operatively after an initial negative COVID-19 swab on admission. A negative swab was obtained 9 days following the initial positive test. Neither patient reported contact with a known COVID-19 positive person but equally had not observed

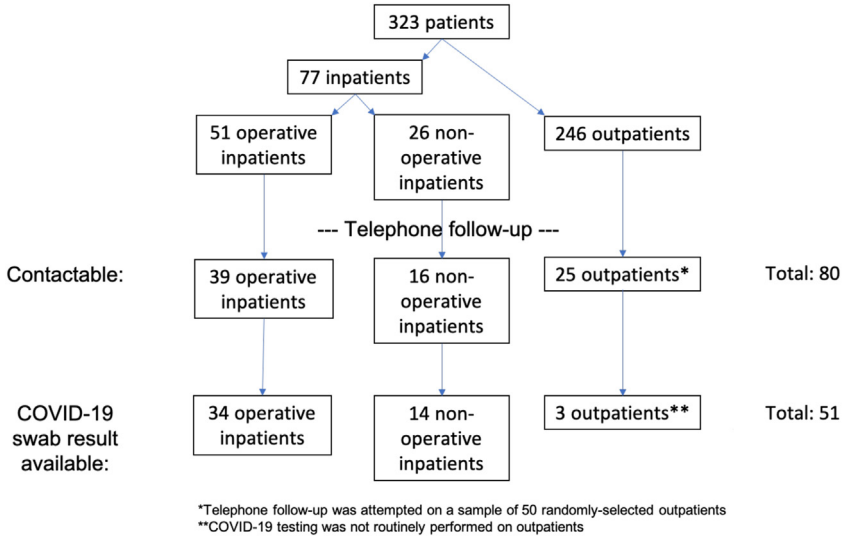

Fig. 2 – Diagram outlining the number of patients in each group of the prospective controlled cohort section of the study. Only those who were contactable by telephone follow-up at 30 days were included in the comparative analysis.

strict home isolation (for medical reasons or otherwise) prior to their burn. One was of BME ethnicity and the other was an elderly male with a BMI of >30 and diabetes. Neither had complications associated with COVID-19. Another paediatric patient had tested positive on a test undertaken at a different hospital 20 days prior to their burn injury. This was undertaken due to symptomatic family members within the household. A negative swab was obtained on admission to the Burns Centre.

A significant proportion of adaptations made in the Burns Centre were designed to prevent transmission between patients. Despite having observed a positive COVID-19 case at the very beginning of the study period (operative paediatric patient), no other patients were found to be infected until the very end of the study period; given the 2 months interim period, these findings suggest that there was no significant COVID-19 transmission between Burns Centre patients. This is important to highlight within the context of our implemented COVID-19 service safety adaptations, especially given the recent data suggesting that 1 in 8 UK hospital cases of COVID-19 were contracted 'on-site' [17].

The Burns Centre has set a standard to achieve rapid COVID-19 test results for all admitted patients. We note that 12.8% (5/39) of patients in the operative inpatient group and 12.5% (2/16) of patients in the non-operative inpatient group did not have test results available. We stipulate that this may be due to rapidly changing protocols in the early stages of the study period. Within a few weeks, a rapid swab turnaround system was established. From that point onward, non-emergency theatre cases were only undertaken when a COVID-19 swab result was available.

During the study period there was an increase in the total number of patients seen, despite the fact that there has been a significant reduction in trauma emergencies nationally [21]. This is likely due to the fact that our unit was protected as a designated national Burns Centre, with protected capacity. The number of operations and bed occupancy days fell, the former by 24.7% and the latter by 27.5%, despite an increase in referrals compared to the same period in the previous year (Fig. 1). The reduction in the number of operations likely reflects a focus away from operative management and a drive towards reducing length of stay in line with NHS Coronavirus guidance to support early discharge [22]. No specific guideline or protocol for adjusting surgical management decisions was introduced in the department as a result of the pandemic. However, as a general rule, smaller burns which could be given the "benefit of the doubt" in the adult outpatient setting were managed conservatively, allowing for the possibility of slightly longer healing times than we would normally accept (>3 weeks). Decision-making in paediatric outpatient burns remained largely unaffected by the pandemic, although more follow-up arrangements were made closer to the patient's geographical home where appropriate. For inpatient burns, decisions regarding operative management were unchanged by COVID-19, but an emphasis was given to operating under regional or local anaesthesia wherever possible.

To compare our experience to others across the world, a literature search was performed using Ovid® Medline® for keywords including "burn" or "burns" combined with "coronavirus", "COVID" or "pandemic". A total of 14 relevant English language articles were obtained. Of the relevant manuscripts, 4 were written as full length journal articles, and 10 were "Letters to the Editor" regarding various aspects of burn care during the pandemic. Geographical distribution of articles reflected the global nature of the pandemic, with publications from the UK (4) [23–26], mainland Europe (3) [27–29], USA (2) [30,31], China (2) [12,32], Malaysia (1) [33], India (1) [34], and one article with intercontinental authorship [35].

The organisation and provision of burn care services varies significantly on an international basis. Regardless of this, common themes in the adaptation and management of burn cases emerged. Most units worldwide placed an increased emphasis on the use of telemedicine clinics and community care where possible for injury decision-making and follow-up. Further common themes included robust staff training in the use of PPE, reducing staff contact with patients and limiting visitors, and obtaining COVID-19 PCR status of patients prior to surgery.

Given that our centre is based in the UK, we were interested to note that the most of the UK-based published articles (three "letters to the editor," and one contribution to the international article) were from the burns centre in Birmingham. This unit provides a similar service to our own, providing care for the full spectrum of adult and paediatric burn injuries. Their reported experience in care planning and patient management was largely similar to that of our unit. A point of difference is that, while our centre has a self-contained ICU, the Birmingham unit lost the use of their three burns ITU beds on the general intensive care unit. However, they were able to convert their dedicated burns HDU beds into rooms with full ICU ventilatory capability, therefore maintaining their capacity to manage the most seriously ill burns patients [35]. This specific point highlights the fact that, while general recommendations and guidelines can be very useful, there is a significant role for individualised logistical and management decisions that need to be taken on a unit-by-unit basis. These efforts require a great deal of time and planning by experienced and skilled decision-makers, and this burden is not to be underestimated in the context of the increased demands on clinical care, particularly with regard to ITU and anaesthetic staff.

With appropriate precautions, surgical intervention posed no higher patient risk due to COVID-19 in this study. We propose that burns surgery can be safely undertaken in both adult and paediatric patients, provided appropriate pathways are followed. This corroborates with plastic surgery specific studies during the peak of COVID-19 in the UK, including a retrospective review of 364 patients from Oxford [36] and a prospective cohort study of 1620 patients who underwent either surgical (n = 1429) or non-operative (n = 191) management from within our overall plastic surgery centre [37]. The Oxford study showed that only 4 post-operative patients were found to be positive for COVID-19, although the number of tests for the 364 patients included was not mentioned [36]. With significant service adaptations implemented to mitigate COVID-19 related risk, a separate study from our Plastic Surgery Centre recorded no 30-day post-operative/first assessment COVID-19 related deaths (0/1620). Furthermore, only 2.6% of tested patients were positive (6/227), with no increased COVID-19 related risk noted [38].

Large studies promoting a more cautious approach to surgical intervention appeared at a relatively early point in the pandemic. An example of this is the international COVIDSurg

collaborative study [10], which focussed on COVID-19 positive surgical patients, and found that a quarter of these patients died within 30 days of their procedure. Importantly this study did not focus on burns patients and did not examine consecutive patients, nor did it include a comparable control or non-operative group. Furthermore, testing protocols were not clearly defined for patients, such that inclusion bias may have been present; it is also possible that patients with an uneventful post-operative recovery may not have been tested and accounted for in data processing [39]. The data collected from the St Andrew's Burns Centre comprises a younger cohort of patients compared to the aforementioned studies (median age 23.5 years, range <1–89 years), which may be protective against adverse COVID-19 related outcomes [7]. While we acknowledge the 63.0% (80/127) patient response rate to telephone follow-up in the prospective controlled cohort part our study, this did not affect the overall prospective cohort study data that indicated a 0% 30-day COVID-19 related death rate.

We therefore believe that our data shows that acute burn care and surgery can be delivered safely and without significant COVID-19 related morbidity during the ongoing pandemic. Given that a conservative approach to burn care may lead to more revision surgeries later, it is important that services adapt appropriate management pathways and protocols, which will deliver safe and timely care. Our data offers a clear representation of burn care at a large national Burn Centre, during the UK pandemic peak (April–May 2020). This information will help guide future burn care provision and determine resource allocation as the pandemic progresses.

6. Conclusion

The COVID-19 pandemic has severely compromised the delivery of healthcare internationally. While elective procedures are planned and can be curtailed, burn injury requires prompt emergency care, and we must design services to deliver this in the safest manner to patients, relatives and staff. As outlined above, continued safe burn care delivery was achieved within the framework of our described COVID-19 service response. In order to achieve this, a focus on the prioritisation of patient management and systems processes was required. As a more severe second wave of COVID-19 becomes a very real possibility, these data can provide some hope for patients. With straightforward adaptations, we have shown that high quality burn care can continue, with high associated patient satisfaction scores, whilst keeping patients safe during the UK pandemic peak. With appropriate precautions, burns patients are not exposed to an increased COVID-19 risk; furthermore, we have demonstrated that there is no increased risk when undergoing operative inpatient management, compared to non-operative inpatient or outpatient treatment. This will help to guide future burn care provision and resource allocation as the pandemic progresses.

Authors' contributions

AS - Lead author, BM - Study inception and manuscript drafting, BS - Data collection, methodology and manuscript drafting, RJ - Data collection, RPL - Statistics, WK - Manuscript review and drafting, NM - Manuscript review and drafting, NEM - Manuscript review and drafting, DB - Manuscript review and drafting, OS - Manuscript review and drafting. All authors read and approved the final manuscript.

Consent for publication

Not required.

Availability of data and materials

Within the manuscript.

Ethics approval and consent to participate

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Competing interests

None declared.

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