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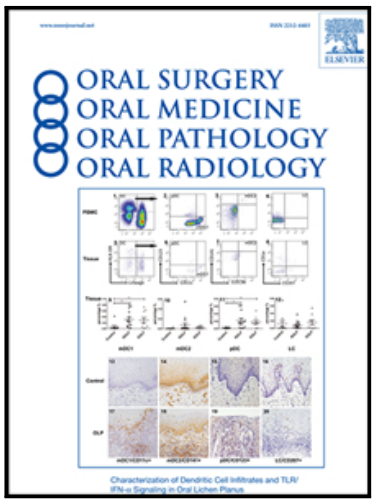

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ABSTRACT

Introduction: The COVID-19 pandemic caused delays in medical and surgical interventions in most health care systems worldwide. Oral and maxillofacial surgeons (OMS) delayed operations to protect themselves, patients, and staff. This manuscript presents (1) institution's experience in management of pediatric craniomaxillofacial (CMF) trauma during COVID-19 pandemic, and (2) suggests recommendations to decrease transmission.

Materials and Methods: This was a retrospective review of children 18 years or younger who had an operation at Children's Healthcare of Atlanta (CHOA) in Atlanta, GA from March to August 2020. Patients were: (1) 18 years old or younger, (2) had one or more maxillofacial fractures, and (3) had an operation by OMS, Otolaryngology, or Plastic Surgery. Medical records were reviewed regarding: (1) fracture location (2) COVID status, (3) timing, (4) personal protection equipment (PPE), and (5) infection status. Descriptive statistics were computed.

Results: 58 children met inclusion criteria. Most commonly injured maxillofacial location was nose. Operations occurred 50.9 hours after admission. Specific prevention perioperative guidelines were used with all patients with no transmission from a patient to a healthcare worker.

Conclusions: With our recommendations, there was no transmission to health care workers. We hope that these guidelines will assist OMS during COVID-19 pandemic.

KEY WORDS: children, craniomaxillofacial trauma, COVID-19

INTRODUCTION

During December 2019, a series of unexplained pneumonia cases were reported in Wuhan, China. The causative organism was found to be severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In February, 2020, the World Health Organization (WHO) officially named the disease 2019-nCoV coronavirus disease (COVID-19).[1,2] The virus causes mild symptoms (e.g. mild rhinorrhea, cough)[3-5] which can rapidly progress to acute respiratory distress syndrome (ARDS), need for ventilator support, and potentially death.[6] Some children develop multisystem inflammatory syndrome (MIS-C) (ref) but most children are unaffected.[7] The mechanism for resilience is unknown. Therefore, children have the potential to be asymptomatic carriers and may contribute to virus transmission in the community.

Human to human transmission occurs[9,10] from symptomatic and asymptomatic carriers.[11,12] Transmission is thought to occur mainly through respiratory droplets.[13] Droplets can be detectable in aerosols for up to three hours. Contaminated surfaces also transmit virus (e.g. copper: 4 hours, cardboard: 24 hours, plastic/glass/stainless steel: 2-3 days).[14] Other similar viruses [e.g. SARS coronavirus, Middle East Respiratory Syndrome (MERS) coronavirus or endemic human coronaviruses (HCoV)] have been shown to persist on fomites for up to 9 days.[13-15] Viral RNA has been found in stool samples from infected patients.[16]

The structure of this virus consists of a lipid envelope, which is disrupted by specific disinfectants within 1 minute (e.g. 60% ethanol, 0.5% hydrogen peroxide, 0.1% sodium hypochlorite).[17] Other biocidal agents such as 0.05–0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate are less effective. The ultimate disinfectant has not yet been discovered.

The COVID pandemic has put unprecedented challenges on the global medical community. To decrease the impact and mitigate the number of COVID-19 cases, national and local government agencies instituted social distancing, eliminated social gatherings, and encouraged appropriate hand hygiene. Many states, counties and cities declared a state of emergency with orders to close all non-essential business and shelter in-place. The potential for domestic violence, physical altercation, unsupervised children, burglary and crimes was expected to surge. Therefore, pediatric craniomaxillofacial (CMF) trauma continued to occur.

Guidelines for diagnosis and treatment of COVID-19 have been constantly changing since the pandemic arrived to United States (US).[19,20] Uniform guidelines for surgical interventions of a child with CMF trauma do not exist. The purpose of this manuscript is to (1) present our institution's experience in management of pediatric CMF trauma during COVID-19 pandemic, and (2) suggest guidelines and recommendations to decrease transmission.

MATERIALS AND METHODS

This study was approved by the Children's Healthcare of Atlanta (CHOA) Institutional Review Board (#17-039). This was a retrospective chart of children 18 years or younger who presented to CHOA from March to August 2020. Patients were identified by reviewing operating room case log. Patients were included if they: (1) 18 years old or younger, (2) diagnosed with one or more maxillofacial fractures, and (3) had an operative intervention by

Oral and Maxillofacial Surgery (OMS), Otolaryngology, or Plastic Surgery services. Exclusion criteria were patients (1) receiving non-operative treatment (i.e. bridle wire, diet modifications), (2) isolated dental trauma, (3) isolated odontogenic infection, and (4) incomplete medical records. Medical records were reviewed to record: (1) fracture location (2) patient COVID status, (3) timing of repair, (4) use of personal protection equipment (PPE), (5) conversion/infection status (i.e. positive patient infecting staff). Descriptive statistics were computed to summarize findings and transmission rate according to our newly developed guidelines.

RESULTS

There were 9423 patients who had a surgical intervention in operating room at CHOA during March to August 2020 (first 6 months of COVID-19 pandemic). Of them, 58 met inclusion criteria. Injury location was nose (n=24, 41.4%), mandible (n=16, 27.6%), soft tissue (n=8, 13.8%), zygomatic complex (n=4, 6.9%), orbit (n=3, 5.2%), or complex involving more than one operative site (n=3, 5.2%). Surgical interventions took place on 50.9 hours after admission (range 4 hours to 11 days PPE was used with all patients. Strict COVID prevention guidelines (to follow) were used with all patients. Following these guidelines, there was no transmission from a patient to a healthcare worker.

DISCUSSION

Definitions

Every child with CMF trauma requiring admission was screened for COVID-19 infection. Suspicion for COVID-19 was based on recent travel, sick contacts, and symptoms. Child was placed in appropriate category based on COVID-19 status: unknown status (prior to investigation), patient under investigation (PUI), COVID-19 positive patient (as a result of a positive test), or COVID-19 negative patient (as a result of a negative test). Providers treated all patients (even COVID-19 negative patients) with the same precautions.

Preoperative testing

Procedures involving upper airway mucosa (intubation, tracheostomy, oropharyngeal procedures) were considered 'high risk' due to aerosolization of the virus which is known to be in high concentration in these areas.[1,24] When viral particles become aerosolized, they stay until complete air exchange or settling (1-3 hours).[1,2]

We recommend obtaining pre-operative COVID-19 status for all patients when operating in and around the face as close as possible to operation. Instrumenting potentially infected mucosal tissue for the purposes of fracture fixation is equivalent to the powered microdebriders/shavers used in sinus surgery. This process would likely lead to increased risk of transmission and droplet diffusion through the operating room.[24,25] At CHOA, when a patient is admitted with CMF trauma, he/she undergoes rapid COVID-19 testing in preparation for potential surgical intervention. However, because of potential for a false-negative result, health care providers should assume that all patients have a positive status and maintain appropriate precautions.

Treatment Indications

Available literature presents various indications for surgical treatment of pediatric facial fractures. In children, surgeons achieve accurate bone reduction and stable fixation to permit bone healing and avoid disturbing future skeletal growth and dental development. Thus fracture management in younger patients can sometimes be non-surgical. As the facial skeleton matures, more conventional and 'adult-like' surgical approaches become appropriate (Lorenz 23). Children can often follow a soft diet as they slowly return to normal function. During COVID pandemic, this thought process allowed some patients to receive appropriate treatment without additional risk of exposure to COVID-19 in operating room.

Timing of Surgical Intervention

During first 3 months of COVID pandemic, most health care systems nationwide cancelled all elective operations. Surgeons continue to provide care during emergent and urgent situation. In general, pediatric facial fractures which require surgical intervention, should receive definitive care as soon as it safe to do so or within 7-10 days. If the repair of a facial fracture is delayed longer, compromised functional and/or cosmetic outcome may occur. These secondary deformities (e.g. temporomandibular joint ankylosis, enophthalmos, facial deformity, etc.) are typically difficult to correct secondarily. Accordingly, in our cohort, CMF which required operative intervention occurred within 50.9 hours after admission.

We recommend dividing all operations into four categories: emergent, urgent, time sensitive and elective (Table 1). Emergent cases consist of fractures resulting in uncontrolled bleeding or causing airway compromise, and uncontrolled bleeding from facial structures that resulted from other conditions (e.g. pseudo aneurysm, anterior/posterior nasal bleeding) that would lead to airway compromise. Urgent cases cannot be treated at bedside and surgical intervention should be completed within 12 hours (e.g. orbital blowout fracture with muscle entrapment, extensive facial lacerations, ear avulsion, unstable dentoalveolar fracture). Time sensitive cases should be treated within 5-7 days, but sooner if possible. Examples are displaced nasal bone/septum fracture with airway obstruction, displaced NOE, Le-Fort I, II, III fracture, displaced ZMC fracture, orbital wall fracture without muscle entrapment, and/or mandible fracture (with malocclusion/deformity requiring ORIF). In addition, any surgical repair of CMF trauma which would expedite discharge from the hospital should occur as soon as possible. Elective cases do not interfere with daily form and function, and should take place only when it is safe to do so. In our cohort, all fractures were in the time-sensitive category. This suggestion provided adequate time to obtain COVID results and preparation of operating room and equipment.

A tracheostomy is sometimes performed as a part of complex CMF repair. Tracheostomy has a high risk of transmission via inhalation, contact with infected respiratory secretions, close proximity, and positive pressure ventilation.[24] In order to decrease viral transmission, we recommend avoiding tracheostomy if at all possible. Instead, surgeons should consider submental intubation or dividing a prolonged operation into multiple shorter ones in order to decrease potential need for prolonged intubation and/or a tracheostomy. In our cohort of patients, none required a tracheostomy.

PPE Equipment

Universal precautions consist of a high level of PPE and enhanced vigilance to appropriate fitting protective equipment (Table 2). Health care workers must be trained on putting on PPE (i.e. donning), perform clinical duties with PPE, and remove PPE (i.e. doffing) in the context of their current and potential duties.[26] Training material should be easy to understand and available in the appropriate language and literacy level for all workers.[27,28] It is important to note that a recent Cochrane review found low- to very low-certainty evidence that covering more parts of the body leads to better protection but usually comes at the cost of more difficult donning or doffing and less user comfort, and may therefore even lead to more contamination. More breathable types of PPE may lead to similar contamination but may have greater user satisfaction. [29] Powered Air Purifying Respirators (PAPR) have certain limitations (e.g. emit unfiltered air flow and may not be safe for members of surgical team not using a PAPR, lack of disposable parts or ability to sterilize, inability to accommodate a headlight, etc.).[30]

We recommend using most effective PPE possible that allows completion of operation without compromising surgical steps. We recommend the following head and neck protection: respirator or fit-tested N95 mask covered by a disposable surgical mask, head/neck cover, goggles, and face shield. We recommend a fluid-resistant gown, double gloves, and shoe covers[31] (Table 2). Doffing should consist of a one-step glove and gown removal and extensive hand washing after all PPE is removed.[26] We also recommend donning and doffing with a partner, discussing the process, and providing real-time feedback. PPE should be discarded in a dedicated and labeled COVID container. Non-disposable equipment such as goggles and face shield should be cleaned according to individual institutional guidelines.

Operating Room Equipment

Typically, every institution has separate guidelines with some similarities between hospitals. All operating rooms (OR) remain positive pressure for surgical infection control. Rooms are at 20 air changes per hour (ACH). Our institution designated one specific OR as the COVID-19 OR. If a surgical procedure took place on a known COVID-19 positive patient, that OR was utilized. All non-essential equipment and supplies were removed from that room and from path to the room. In general, the anesthesia ventilators have appropriate filtration to prevent aerosolization. In case a patient requires hand mask/bag, high efficiency particulate air (HEPA) filters are in place. If a COVID-19 positive patient remains intubated postoperatively, transportation should occur on a ventilator to a specified COVID-19 room in the intensive care unit (ICU). Handoff will occur bedside in the COVID-19 ICU with both the OR and ICU teams present. None of our patients required prolonged intubation and/or transport on a ventilator.

Our institution developed a specific protocol for cleaning the OR and recovery room after presence by a patient with COVID-19. After aerosolizing procedures, we recommend closing and taping the OR doors for 15 minutes without allowing entry to anyone. Then, a terminal clean should be completed via ultraviolet protocol.[27]

Operating Room Staff

OR staff consisted of 3 teams (anesthesia, surgery, staff) with 2 members in each team (attending and resident/fellow or circulator and surgical tech) except in extenuating circumstances. Many institutions suspended clinical rotations by medical students, including participation in operations. All personnel in the room should wear N95 masks and similar PPE secondary to the high-risk of aerosolization. Only anesthesia should be in the room during induction. Where indicated, the OR team can assign an additional outside circulator/runner.

CMF TREATMENT MODIFICATIONS

The purpose of modifications in treatment of pediatric CMF trauma is to decrease the length of operating time, which decreases overall exposure to virus by surgeon and OR staff.[32] When appropriate, non-surgical interventions (i.e. diet modifications) are preferred (e.g. a child with primary dentition). We present the following specific strategies which we have been following which resulted in zero transmission rate during the COVID-19 pandemic:

Statement of Clin Rel

The COVID-19 pandemic brought unprecedented challenges to Oral and Maxillofacial Surgeons (OMS). Some operations were modified to protect patients and staff. In this manuscript we present our center's guidelines and recommendations in treating children with craniomaxillofacial trauma during pandemic.

1. Oral cavity should be irrigated with 0.5% peroxide for 60 seconds prior to procedure to decrease viral load.
2. Electrocautery and bipolar electrocautery should be used on lowest voltage possible to minimize plume.
3. All attempts should be made to treat fractures with closed reduction (i.e. maxillomandibular fixation, MMF).
4. When performing closed reduction, if possible and appropriate, all attempts should be made to use hybrid arch bars, intermaxillary fixation (IMF) screws, ivy loops, etc., instead of traditional arch bars. This is done in an effort to decrease time in the OR.
5. For open reduction and internal fixation (ORIF), choose transcutaneous approach instead of intraoral approach where possible and appropriate.
6. During ORIF, use self-drilling screws when possible.
7. Consider remove of MMF appliances at end of the case if appropriate. This will likely decrease the possibility of need to return to OR for removal.
8. If possible, resorbable sutures should be used.
9. Follow up care
    a. Inpatient visit by surgical team by only one member of surgical team
    b. In-person post-operative visit 5-7 days after the operation only if absolutely necessary. This decreased patient traffic in the hospital/outpatient clinic.

c. Telemedicine should be used if possible and for additional post-operative visits, if appropriate.[33]
d. During post-operative visit, only one surgeon should enter the patient room.

CONCLUSIONS

OMS have never faced challenges similar to COVID-19 pandemic. The sudden arrival did not decrease the need for surgical interventions of CMF trauma in children. Following our specific recommendations, we have had no transmission to health care workers. Therefore, it is our hope that guidelines presented in this manuscript will assist OMS when providing treatment to a child with CMF trauma during COVID-19 pandemic.

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Table 1: Timing of Surgical Intervention

	Timing to completion	**Examples**
Elective	can be postponed >4 weeks	• Revisions • Bone/cartilage grafts
Time sensitive	completed within 1-2 weeks	• Displaced Nasal bone/septum fracture causing nasal airway obstruction • NOE (Markowitz type 2 or 3) • Le Fort fracture (I, II, III) • Displaced ZMC fractures • Orbital wall fracture without evidence of muscle entrapment • Mandible fracture • Repair of CMF trauma that will expedite discharge from hospital
Urgent	completed within 24 hours	• Orbital blowout fracture with muscle entrapment • Extensive facial lacerations • Ear avulsion • Unstable dentoalveolar fracture
Emergent	completed immediately	• Fracture resulting in uncontrolled bleeding or causing airway compromise • Uncontrolled bleeding from facial structures that resulted from other conditions (e.g. aneurysm, anterior/posterior nasal bleeding) that would lead to airway compromise

Table 2: Personal Protective Equipment (PPE) *FDA approved

Equipment*	**Protection**
Fit-tested N95 mask	Against inhalation of virus
Disposable surgical mask	Protects N95 mask
Head/neck cover	Decreases skin/hair exposure
Goggles	Eyes, decreases conjunctival exposure
Face shield	Skin not covered by above
Fluid resistant gown	Clothes, skin
Double gloves	Hands, wrists
Shoe covers	Protects shoes