10.1 Introduction

The impact of the novel coronavirus (SARS-nCoV-2) on trauma care extends far beyond the direct consequences of an infection in an individual. The presence of this contagious disease in our society presents unprecedented challenges for healthcare systems, impacting the care for trauma patients on a system-wide level. The COVID-19 pandemic demands unseen system-wide measures by healthcare authorities to protect the public from this disease. Societal measures and restrictions change the epidemiology of trauma, prompting trauma care networks to adjust their operation. Ensuring continued access to trauma care aside navigating the local healthcare response to an expanding number of COVID-19 patients demands additional resources and updated standard protocols. On an individual level, all emergent admissions to trauma hospitals are to be considered cases to keep healthcare workers safe. Lastly, a trauma in a patient with COVID-19 can present with unique challenges.

10.2 Epidemiology of Trauma Amidst the COVID-19 Pandemic

The worldwide community spread of COVID-19 in 2020 was met by unprecedented measures to protect the public in many countries. National and regional authorities across the globe implemented directives to limit the spread of the virus. Actions ranging from social distancing to stay-at-home orders profoundly influence daily
interactions in society. These actions affect the epidemiology of many conditions and societal problems, including injury.

Various states and countries implementing stay-at-home orders saw a significant decline in trauma admissions to major trauma centers during the time the orders were active. The state of Washington implemented stay-at-home orders early March 2020, resulting in a decrease in trauma admissions, without significant changes in trauma severity in the months following this order at Harborview Medical Center, which is the only level 1 pediatric, and adult trauma center in the Pacific Northwest. Admissions increased again with the progressive lessening of societal measures to limit spread, including the lifting of the statewide stay-at-home order at the end of May (Table 10.1: Harborview Medical Center Trauma Census and Injury Severity).

Decreased social interactions result in less road traffic and fewer mass gatherings, ultimately reducing the sheer number of opportunities for an individual to sustain an injury. Many European countries have seen traffic volume decline between 50 and 75% compared to the 5-year monthly average from the years preceding the 2020 COVID-19 pandemic [1]. France and Spain have reported 40–70% fewer fatalities due to road accidents compared to the monthly average for the same months from 2014 to 2019. This observation occurred despite a concurrent increase in speeding offenses caught by automated cameras in the same countries. In the United States, a similar rise in speeding offenses was reported in several states with stay-at-home orders by the Governors Highway Safety Association, an organization assessing the safety of the US highway network [2]. New York City has seen the number of speeding offenses in April caught by automated cameras doubled compared to the year before, despite being one of the epicenters of the US COVID-19 epidemic. Los Angeles has seen a 30% increase in speeding offenses prompting city management to make changes to the timing of pedestrian and traffic signals to improve safety. Minnesota saw an increase in both car crashes and fatalities in April of 2020 compared to the averages in April of 2019. Massachusetts reported doubling of roadside fatalities in April of 2020 compared to 2019, despite a decrease in overall motor vehicle crashes. Nevada and Rhode Island reported an increase in pedestrian deaths

| Table 10.1 Harborview Medical Center trauma census and injury severity |
|---------------------|---------------------|---------------------|
|                     | 2015–2019 | 2020 | Decline (%) |
| March counts        | 482      | 410  | −15          |
| March ISS           | 11.6     | 10.6 | −8           |
| April counts        | 466      | 321  | −31          |
| April ISS           | 11.5     | 12   | +4           |
| May counts          | 577      | 526  | −9           |
| May ISS             | 12.1     | 12.3 | +2           |
| Overall counts      | 1525     | 1257 | −18          |
| Overall ISS         | 11.7     | 11.5 | −2           |

Overview of the number of trauma admissions during the months where a stay-at-home order was active in the State of Washington (March 18–May 31) compared to the 5-year average of the preceding years for the same month. ISS Injury Severity Score
after being hit by motor vehicles. These data show an overall change in the behavior of motorists due to the societal consequences of the COVID-19 pandemic, leading to altered epidemiology of roadside trauma.

COVID-19 profoundly impacts society, both due to the burden of disease and due to the measures taken by the governments to contain the epidemic within their territory. Many families and individuals see their financial, social, and healthcare situation jeopardized. These increased stressors combined with stay-at-home orders seem to lead to an increase in domestic violence. According to United Nations Women, reports of violence against women and girls have increased parallel to the implementation of statewide lockdown orders in various nations in Asia, Europe, North America, and South America [3]. In the United States, though hard to quantify with only data from a limited time period available, there have been fewer reports of child abuse despite hospitals subjectively reporting increased severity of injuries in children suffering domestic abuse who are being admitted. Authorities closing schools and daycare centers as part of their efforts to reduce the spread of the epidemic should be aware that this limits opportunities for external providers and family members to notice warning signs prompting concerns of child abuse. In many countries taking society-wide measures, such as stay-at-home orders, accessibility of services helping victims of domestic violence may be severely reduced. Healthcare providers involved in primary and/or trauma care should be aware of these changes in the epidemiology of domestic violence and make efforts to prevent and identify cases. Institutional policies may need to be adapted to ascertain the safety of suspected victims of domestic violence with access to safe-houses, psycho-social, judicial, and protective services potentially being more restricted due to lockdown measures taken by local authorities.

With the overall decline in interpersonal contacts seen with national and regional stay-at-home orders, non-domestic interpersonal violence has overall decreased in most countries. However, some countries have reported an increase in violence against healthcare workers, mostly in healthcare systems that have been overwhelmed by COVID-19 patients, thus reducing the availability of immediate care to those seeking it. Hospitals need to be aware of this and may need to adjust staffing and security to avoid escalation of verbal violence to physical violence, potentially leading to injury of essential healthcare workers.

In summary, most regions globally have seen a decline in the trauma census. A reduction in traffic volume has not led to a decrease in fatalities everywhere, as some areas report increased speeding and reckless driving on less busy roads. Lockdown orders have led to an increase in domestic violence in many countries. Trauma hospitals need to be aware of these changes in the epidemiology of trauma resulting from the COVID-19 pandemic, and the different measures authorities have taken to limit the spread of the virus. Staffing and institutional policies may need to be updated to accommodate victims of interpersonal violence with access to support services potentially being more limited.
10.3 Trauma Care During a Pandemic

Trauma management during the pandemic involves adequately treating non-elective patients while minimizing risk and exposure to the healthcare workforce. While trauma numbers and caseload will vary during the pandemic, ultimately, trauma will continue to bring patients into a health system that is already stressed by the rising COVID-19 workload. Given that most Level 1 trauma centers are also the regional referral center for other specialties, often with the largest quota of intensive care unit (ICU) beds, these centers have often become overwhelmed during the COVID-19 pandemic, and it is at times challenging to sustain historical trauma center operations. Staff have needed to be redeployed to care for COVID-19 patients, and non-critical trauma center functions such as trauma outreach and prevention, research activities, administrative meetings, and educational courses have been halted. As such, the Medical Director and Program Manager for the trauma services should be actively involved with hospital planning and development of ICU triage, surge capability and capacity, cross-training of ICU providers, and protection of all hospital staff [4]. Specific data points for critical trauma center functions (e.g., operating room, ICU, emergency department, blood bank, radiology, and surgical availability) should be reviewed daily by the trauma leadership [5]. Triaging of patients to the center with the highest trauma center designation may need periodic re-examination and prioritization of high acuity injuries only, with the diversion of minor trauma at peripheral sites with telemedicine guidance from the major trauma center.

All staff should be trained in the usage of adequate personal protective equipment (PPE) (Levels 1–3 and their respective indications; see Table 10.2). With an increasing demand for PPE, correctly using the appropriate level of protection is essential.

Table 10.2 Levels of PPE with clinical applications (Gong et al. Anesthesia Considerations and Infection Precautions for Trauma and Acute Care Cases During the Coronavirus Disease 2019 Pandemic: Recommendations from a Task Force of the Chinese Society of Anesthesiology. Anesth Analg ePub)

| Application                        | Level 1 | Level 2 | Level 3 |
|------------------------------------|---------|---------|---------|
| Work clothing                      | +       | +       | +       |
| Fluid resistant gown               | +       | +       |         |
| Latex/nitrile gloves               |         |         |         |
| Surgical facemask                  | +       |         |         |
| >95% efficiency particle filter respirator ((K)N95, FFP2 and above) | +       | +       |         |
| Goggles/face shield                |         |         |         |
| Application                        |         |         |         |
| Low exposure risk clinical work: e.g., imaging technicians | Moderate to high risk of exposure clinical work: e.g., Emergency dept. triage nurse | Aerosolizing procedures: e.g., intubation |
Systems should be in place to decontaminate and recycle PPE, such as powered air-purifying respirators (PAPR) and N95 masks. COVID-19-positive patients should be treated to minimize the aerosol spread and fomite production with scrupulous hand hygiene, universal masking in place, and adequate decontamination of areas.

10.3.1 Prehospital Measures

For paramedic and emergency medical services (EMS) responders, given the proximity to patients and other members of the public, all patients should be presumed COVID-19 positive. Therefore, prehospital providers should wear a minimum of Level 2 protection in communities where COVID-19 is prevalent. Screening based on symptoms and examination findings of febrile respiratory illness is not sensitive enough for the diagnosis of COVID-19 in the prehospital setting [6]. Therefore, emergency call takers and dispatchers cannot reliably triage patients into risk categories to minimize PPE use by prehospital providers. If possible, minimizing the number of staff being exposed will reduce PPE usage and decrease risk. In EMS systems that operate a tiered-response system, only the first crew to arrive should enter the scene and assess the need for extra personnel to minimize entry and exposure by other providers. Air medical services should assess the flammability of different types of PPE and introduce procedures to don and doff PPE at appropriate times to minimize fire hazards. Surgical masks should be applied to patients before moving them from a scene to the hospital and where able patients should undertake hand hygiene. Severely hypoxic patients may need to be intubated in the field before transfer (see recommendations below). All equipment used on these patients should either be discarded or appropriately sterilized. EMS crews may be requested to obtain nasal COVID-19 reverse transcriptase-polymerase chain reaction (RT-PCR) swabs in deceased patients to track COVID-19 mortality accurately. While myocardial infarction and stroke admissions seem to have decreased during the acute pandemic stage, it is not clear yet if there is delayed or no self-presentation of certain trauma patients in the emergency department.

10.3.2 Hospital Trauma Bay

Potential COVID-19 patients requiring emergent intubation should follow a strict protocol that ensured that the most experienced airway practitioner instruments the airway. Elective intubation in the ED to minimize exposure during the transportation is often appropriate.

Many institutions’ emergency departments have become overwhelmed during the pandemic as the rate of influx of new patients outpaced the ability of the institution to open appropriate beds (general ward, operating room (OR), or the ICU). Overall, managing COVID-19 patients under investigation (PUI) slows down patient movement with an added layer of complexity with all areas of management. Therefore, managing patients expeditiously will avoid the ED from becoming overwhelmed.
10.3.3 COVID-19 Triage/Rule out

To enable adequate precautions and appropriate management within the hospital system, patients need to be triaged as to the likelihood of COVID-19 status as rapidly as possible. Over and under triaging, both pose risks for the patient and the healthcare system. Triage has been managed in different ways depending on community prevalence of COVID-19, healthcare resources, availability, and rapidity of RT-PCR testing and imaging.

Screening can be based on symptoms obtained at the time entry into ED, whereby all patients are asked about exposure to COVID-19 patients, and if they are experiencing fever, cough, shortness of breath, or diarrhea. Any patient screening positive is given a surgical mask, cohort into a separate area, and treated as presumed positive until further testing is done. This, however, may overburden the system as well as miss asymptomatic carriers. Many trauma patients, especially those with severe illnesses and those with neurotrauma, are not able to provide a reliable history.

Triage has been based on whether the patient has a fever >100°F and/or bilateral infiltrates on chest X-ray, in which case they are presumed COVID-19 positive. Lung ultrasound is relatively sensitive for pneumonitis and so, while not specific for COVID-19, has been used in ED to triage patients. Given that most severe trauma patients undergo some form of point of care ultrasound/extended focused assessment with sonography in trauma (FAST) scan, this method could be used. Lung contusions may make this harder and require adequate operator training. Many trauma patients undergo computed tomography (CT) scans, which will cover the thorax. Patchy ground-glass opacities in multiple bilateral pulmonary lobules with peripheral distribution are typical COVID-19 CT chest features, and therefore CT has been used to triage patient COVID-19 status. Caution is warranted; however, as viral pneumonia and aspiration of gastric contents and blood that often occurs in trauma, patients may present with similar radiological findings on CT chest [7]. There are several documented cases of picking up asymptomatic COVID-19 patients in trauma via CT scan [8, 9].

Nasopharyngeal RT-PCR swabs are presumed to be the gold standard for detecting the presence of COVID-19 viral disease, and the availability of testing with rapid turnaround is essential to utilize healthcare resources adequately. However, false-negative rates are significantly high at times, and ideally, RT-PCR should not be used alone, and the clinical and epidemiologic situation should be carefully considered. If the pre-test probability is high, the patient should be treated as COVID-19 positive with further imaging and repeating RT-PCR testing, including testing an endotracheal aspirate in intubated patients. Whenever possible, endotracheal sampling should be preferred over nasopharyngeal sampling [10].

10.3.4 Transport of the Patient

Effective communication and coordination between staff with peer-to-peer signout and completion of documentation is imperative before any patient movement.
Ideally, hospitals should have designated COVID-19 pathways and elevators for patient transfer.

Non-intubated PUI and COVID-19-positive patients should be transported wearing a surgical mask and should proceed directly to the OR and not via a preoperative holding area. Any staff moving these patients should wear a minimum of Level 2 PPE and should help with patient positioning in the OR before departing from the OR to minimize exposure of further staff and conserve PPE. The handover of the patient should be clear and concise. A doffing of PPE area for transfer staff in the OR suite should be identified, and further PPE supplies (including scrubs) should be available for these non-OR staff.

10.4 Surgical Interventions (Fig. 10.1)

Elective surgeries should ideally be postponed until necessary [11]. This will reduce unnecessary patient traffic in the hospital and decrease the introduction and spread of disease between symptomatic and asymptomatic patients and also the healthcare staff. Also, reducing surgeries allows planning for surge capability, saves resources, including hospital beds and PPE, as well as preserving the health of the surgical team. There is also increasing evidence that COVID-19 patients undergoing general anesthesia are at increased risk of post-op pulmonary complications. The drawbacks of postponing surgeries may lead to more prolonged ICU or hospital length of stays, as out of hospital discharges to skilled nursing facilities, or rehabilitation centers may be dependent on a negative COVID-19 test at the time of anticipated discharge.

Hospital policies and care pathways for managing patients in the operating room with known or suspected COVID-19 infection must be developed, thereby preventing delays in critical operative interventions for unstable patients (see Fig. 10.1). For urgent cases, delay to surgery should not compromise care; cases should preferentially be performed at times of day when staffing and resources are optimal; and after RT-PCR or CT, scan results are available. Patients’ symptoms inconsistent with COVID-19, or no radiologic findings, or have a negative RT-PCR test, should be managed in the OR with standard operating room precautions, thereby preserving resources in COVID-19-negative cases. Anesthesiologists may use N95/FFP2-3 masks in these patients, if available.

Where possible, ORs should be explicitly designated for suspected and confirmed COVID-19 patients. Collocating these rooms away from high traffic areas optimizes patient flow and resource utilization and decreases disease spread. The operating room should conform to negative pressure airflow. The negative pressure system should be turned on half an hour before the patient is moved in. The operation should be performed when the negative pressure reaches $-5 \text{ kPa}$ or lower. If this is not possible, a high-frequency air exchange ($\geq 25 \text{ cycles/h}$) is preferred. Ideally, these ORs should have their ventilation system with an integrated high-efficiency particulate air (HEPA) filter. Traffic and flow of contaminated air can be minimized by locking all doors to the OR during surgery. There should be only one possible route for entry/exit. Warning signs should be placed outside the OR. PPE should
be readily available with designated areas for donning/doffing. If an anteroom is not available, a taped off area should be marked for these activities just outside of the OR door. Instructional posters on appropriate procedures should be prominently displayed. Surgical staff should be limited to essential personnel to conserve PPE. One should avoid flux of multiple professionals into the room. Doffing of PPE should be undertaken with the guidance of another person. N95 masks and PAPR hood should undergo specific recycling and storage to conserve PPE.

Deploying senior practitioners where possible may enable more efficient case turnover. The pandemic has required rewriting of practitioner work schedules, and while surgical volume may be decreased, in house and on-call staffing requirements may have increased. A 12-h work shift for staff may reduce PPE usage in certain areas.

**Fig. 10.1** Example of workflow pattern for emergent patients at Harborview Medical Center during the COVID-19 pandemic
Before proceeding with surgery, there should be a huddle between anesthesia, surgical, and nursing/allied health teams. The decision to proceed should be based on a likely risk-benefit ratio. It is preferred that patients proceeding to OR should have consideration to code status and for those with anticipated poor prognosis. “Do Not Resuscitate” status should be considered preoperatively, to limit the possibility of cardiopulmonary resuscitation (CPR) in the OR.

All instruments and supplies having disposable alternatives should be used. Anesthesia carts (with adequate medication stock), ventilators, cautery, laparoscopic towers, tables, and all essential equipment should be limited to use in the designated COVID-19 room. It is reasonable to remove unnecessary devices from the OR before surgery. Personal items such as pagers, phones, and pens should not be brought into the OR. Disposable pens should be provided in the room. All disposables should be discarded at the end of the case. Necessary devices, such as computers, anesthesia machines, and telephones, should be covered with disposable plastic wrap.

A “runner” should remain available by phone to service the room and limit entrance and egress during the case. Equipment and medication exchanges can be performed using a material exchange cart placed immediately outside of the room or in the anteroom or via a dual access port.

Communication, while one is in PPE in the OR, is a challenge, especially as non-verbal communication is lost. Using closed-loop verbal communication and speaking slowly, deliberately, is vital. The use of handheld radios, telephones, and writing down instructions to enable communication with the outside of the OR has all been used.

Minimizing cross-contamination in the OR requires scrupulous practice. Ideally, the hands of the patient should be cleaned before coming to the OR, and the patient adequately sanitized peri-op. Regular hand hygiene with alcohol-based hand gel on gloves is recommended. Areas should be regularly wiped down regularly using a quaternary ammonium compound with alcohol. Closed intravenous systems for drug administration should be the norm. Blood samples of COVID-19 patients should be stored in double bags and labeled with a warning sign of “COVID-19.”

It is advisable to limit the number of OR personnel in the room during intubation. Those actively involved with the intubation attempt should wear Level 3 PPE. The patient should be optimally positioned and pre-oxygenated with a well-fitting mask with a good seal and a closed breathing system. Noninvasive ventilation systems and high flow nasal cannulas have variable reports as to their propensity to form aerosols and thus are not recommended for routine intubation. Before induction of anesthesia, a HEPA filter should be connected to the patient end of the breathing circuit. The other of the filter should be connected between the expiratory limb and the anesthetic machine. Equipment should be prepared to reduce the need for circuit disconnections. Disposable equipment should be used where available.

Double gloves should be used routinely during intubation, and the top layer removed following intubation to limit further contamination. To shorten intubation time and maximize the “first-pass success” rate, intubation should be performed by experienced staff.
To enable rapid airway control, a rapid sequence induction should be undertaken. Ideally, the patient should not be bag-mask ventilated to decrease the risk of aerosol formation. However, should the patient be hypoxic, low tidal volume breaths with adequate PEEP are useful. A video laryngoscope is recommended as the first intubation plan because a PAPR hood or goggles may hamper vision during direct laryngoscopy. A video laryngoscope also keeps the intubator farther from the patient’s airway during intubation. However, ultimately, the practitioner should use the intubation method they are most familiar with and comfortable with. Severe hypoxia from COVID-19, as well as lung trauma, may require lung-protective ventilation with adequate PEEP, tidal volumes, and plateau pressures. Recruitment maneuvers intraop to minimize atelectasis may be needed.

The patient should be in a deep plane of anesthesia with an adequate neuromuscular block before the intubation attempts to avoid the patient coughing. The cuff of the endotracheal tube should be inflated before attempting ventilation. For any circuit disconnects, the patient should be pre-oxygenated with 100% oxygen, adequately sedated and paralyzed, the anesthetic gas flow stopped, and the circuit is broken on the machine side of the HEPA filter. If required, the endotracheal tube can also be clamped—this may be necessary if the HEPA filter itself needs to be exchanged. The closed system in line suction can be attached to the circuit to avoid circuit disconnects once the patient is intubated.

Use of supraglottic airway devices such as the laryngeal mask airway (LMA) is not advisable as the first line for airway management due to the risk of gas leakage around the LMA. However, this may be the only airway adjunct available in the prehospital care setting. For difficult airways, standard operating guidelines should be followed. However, it should be noted that there is an increased risk of an aerosol generation with awake fiberoptic intubations, and this is not recommended in COVID-19-positive patients.

Which induction agents to use in trauma patients depend on practitioner familiarity as well as the hemodynamic status of the patient. However, while the data is sparse, etomidate may pose an increased risk to COVID-19-positive trauma patients due to the immunosuppressive side effects of etomidate. COVID-19 can cause immune dysfunction and immunosuppression with the potential of severe infection and multi-organ dysfunction syndrome post-trauma [12]. Thus, emergency surgery should follow the principles of damage control. Surgical manipulation should be minimized, and surgical duration should be shortened. If laparoscopic surgery is being performed, a smoke evacuator attached to a HEPA filtration device must be used during and at the end of the case to facilitate the release of pneumoperitoneum. Use smoke evacuators/filtration device in all cases requiring electrocautery, laser, or ultrasonic scalpels, to limit exposure to aerosols. Closed suction systems such as the Neptune system (Stryker Corporation, Michigan, USA) are ideally suited for this.

In suspected or confirmed COVID-19, the choice of anesthetic technique should be based on the patient’s overall clinical status, trauma condition, and adapted to the surgical treatment. Regional anesthesia is preferred if it can meet the needs imposed by surgical technique and surgeon preference. Patients receiving regional anesthesia
can use oxygen through a nasal cannula, with a surgical mask on top. Neuraxial techniques may cause translocation of the virus into the central nervous system. Coagulopathy from COVID-19, as well as trauma-induced, should be considered.

SARS-nCoV-2 has the propensity to cause cardiac, renal, and coagulation dysfunction. Therefore, serial perioperative monitoring of cardiac and renal biomarker tests is advisable, and advanced cardiac output monitoring/echocardiography considered in unstable patients. Patients should be maintained in a euvolemic state, mainly to minimize secondary lung and renal injury [13]. Coagulation status should be monitored by regular emergency hemorrhage panels or point of care viscoelastic testing and blood gas analysis intraoperatively in trauma patients.

Extubation can be undertaken in the OR or ICU, depending on resources and time. Essential staff only should be present in the OR during extubation, and level 3 PPE should be utilized for those extubating. A technique targeting smooth emergence with minimal coughing is preferable. When possible, the patient should be recovered in the operating room until they can be transferred to an isolation room on the ward or in the intensive care unit. After extubating, the patient will need to remain in the OR for approximately 30 min to allow adequate air exchanges to occur and make sure the patient is sufficiently recovered from the anesthetic. Nasal prongs for oxygenation of the patient with a surgical face mask on top should be used. Venturi masks and high flow systems should be avoided, given their potential to aerosolize viral particles.

Non-operating room anesthetic areas for COVID-19-positive trauma patients, such as interventional radiology, should ideally be organized in the same way as OR suites.

Terminal cleaning of all surfaces should be performed after each operation, following hospital guidelines. This will typically mean that OR turnaround time is increased and other ORs should be available to continue operating. Human coronaviruses can be efficiently inactivated by surface disinfection procedures with 62–71% ethanol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite within 1 min. Surfaces should be wiped down and left to dry [14]. The room can then be sterilized with UV-C for at least 30 min or a hydrogen peroxide vaporizer. If the hospital has the capacity, items such as anesthesia carts can be quarantined for at least 60 h (to ensure natural viral particle breakdown) before reuse. This strategy minimizes waste and enables more equipment and medication to be kept in the OR during the case.

With elective procedures canceled in most hospitals, there is an ever-increasing backlog of surgical cases. Governments, professional bodies, and hospitals are therefore keen to move from a position of curtailment to reopening elective surgery. This, however, requires a low prevalence of SARS-nCoV-2 in the community with easy access to testing and ensuring there are adequate hospital and ICU beds, OR provisions, PPE, trained staff, and other medical supplies. The affect COVID-19 may have on access to safe surgery in low and middle-income countries, and for homeless persons, migrants and refugees are particularly worrisome.
10.4.1 Blood Products

While the cancelation of elective surgery and transplants have decreased blood usage in many areas, community social distancing policies, public fear of donation and disease transmission, and closing of blood donation centers may lead to a decrease in the regional blood availability. Specific blood donation campaigns have been employed to increase public donation during the pandemic, and there is no data to suggest that SARS-nCoV-2 can be transmitted via blood transfusion. Hospital blood stocks should be monitored daily, and restrictive transfusion strategies enforced where appropriate. While cell savers can be used in the OR, this often involves another member of staff being present with the risk and cost that this entails.

10.4.2 ICU

COVID-19 has placed an enormous strain on ICU services worldwide, and therefore ICU capacity, especially for trauma patients, should be monitored daily. The availability of monitors, ventilators, and oxygen supply has often been in critical short supply. COVID-19 positive patients are usually collocated geographically, and so this may often require patients under the trauma service being spread across the hospital site. In hospitals where extra ICU beds have rapidly been increased with urgent up-training of nursing and allied health staff to care for COVID-19 patients, it should be remembered that trauma patients who are also COVID-19 positive will require the most highly skilled nursing staff.

When transferring patients to and from ICU, ideally, hospital transport pathways designated for COVID-19-positive patients should be used. Clear communication and handoff between OR and ICU staff should occur before the movement of the patient. To minimize ventilator circuit disconnects, healthcare worker exposure, PPE usage, and patient movement to and from ICU, medical therapy should be pre-planned, and any imaging or therapy requirements undertaken in a single move.

Trauma patients may return to the OR for multiple surgeries. Therefore, their COVID-19 status based on symptoms and radiological changes should be continuously monitored, and RT-PCR ideally repeated every 72 h until the requirement for surgery has passed. Hospital visitors should be kept to a minimum, and logs should be kept as to which healthcare workers have been in contact with which patients to enable contact tracing should there be a change in positive COVID-19 status.

10.4.3 Rehabilitation and Out-Patient Services

These services have been particularly affected during the SARS-nCoV-2 pandemic, with many services stopping or moving onto telemedicine/online platforms. Every effort should be made to continue this provision as good patient outcomes in trauma are dependent on ongoing rehabilitation, psychiatric, family health, and out-patient services.
10.5 COVID-19 in the Injured Patient

With an essential share of COVID-19 infections occurring asymptptomatically, sustaining trauma while being infected with the novel coronavirus is a risk of unknown magnitude.

Publications assessing the risks of trauma and general anesthesia or surgery in infected individuals are mostly lacking. Trauma patients may need emergent surgery for their injuries. Undergoing general anesthesia while being COVID-19 positive may carry the risk of exacerbation of the pulmonary disease. Currently, no substantial evidence on simultaneous COVID-19 and (poly)trauma exists; however, a large case series provided insight into the correlation of emergent surgery in COVID-19-positive patients and postoperative outcomes [4, 15]. This report pooled outcomes from various COVID-19 patients undergoing different elective and emergent procedures in a single database. Though no control group was used, the authors noted a higher number of postoperative respiratory complications (50.1%), as well as higher mortality than what would be reasonably expected for a similar non-infected cohort. About 10% of the cases in this database were trauma patients, but no conclusions were drawn specifically to this population.

Both general anesthesia requiring intubation with mechanical ventilation and direct injury to the airway, chest or lungs, can worsen the existing underlying pulmonary disease. This is no different for patients who may have a subclinical or asymptomatic SARS-nCoV-2 infection. Both blunt and penetrating trauma to the chest can induce inflammatory changes that may exacerbate an underlying viral infection, thus resulting in a higher risk of adverse respiratory outcomes, such as prolonged mechanical ventilation, ventilator-assisted pneumonia, lung injury, or ARDS. Currently, no evidence suggests trauma patients with COVID-19 benefit from a mechanical ventilation strategy that is different than for non-trauma patients with COVID-19. Trauma may limit clinicians in treatment options for COVID-19 patients. For instance, injury to the spine may preclude the possibility of elevating the head of the bed or placing the patient in a prone position. Patients with chest trauma may have a more limited reserve and require intubation earlier on. Hypoxia and hypercarbia may be less tolerated in patients with significant injury or resulting systemic inflammation. Permissive hypercapnia may not be feasible in a patient with metabolic acidosis following systemic inflammation after polytrauma. Efforts should be made to optimize homeostasis in trauma patients with COVID-19: Increasing hypercarbia worsens acidosis, contributing to systemic inflammation, coagulation, and enzymatic dysfunction and decreased effectiveness of catecholamines.

A more proactive approach to diagnose complications in critically ill trauma patients with COVID-19 is warranted. The threshold to admit COVID-19 patients with concomitant (poly)trauma should be lower than for trauma patients without significant comorbidities, especially in patients with systemic inflammation, chest trauma, or lung injury.

Conflicting reports have been published on the incidence of venous thromboembolism in patients hospitalized with COVID-19. Some institutions have
liberalized their recommendations for venous thromboembolism (VTE) prophylaxis for COVID-19 patients in comparison to non-COVID-19 patients [16, 17]. Other ICUs have started screening patients using ultrasound or have increased their screening frequency. Orthopedic trauma with subsequent immobilization and systemic inflammation both contribute to the risk of developing deep venous thrombi. Trauma patients may be at increased risk of bleeding, or they may have an injury where bleeding significantly increases the risk for an adverse outcome, such as traumatic brain injury patients. Currently, there is too little evidence to support altering the dosing regimen of VTE prophylaxis in inpatients as well as in outpatients who require immobilization for orthopedic injuries. Due to the low risk associated with increased screening efforts, heightened vigilance for the development of VTE in hospitalized trauma patients with concomitant COVID-19 infection may be warranted. Many health systems have standardized the use of tranexamic acid in hemorrhaging trauma patients. The administration of this product may pose a higher risk of thrombo-embolic events in COVID-19 trauma patients due to the possible pro-thrombotic state associated with this disease. With the lack of evidence surrounding tranexamic acid use in COVID-19 trauma patients, the decision to use tranexamic acid in severe trauma should be made on a case by case basis. The use of perioperative sequential compression devices (SCD) is advisable if there are no other contraindications.

Multiple reports describe processes of microthrombosis, intrapulmonary hemorrhage, or diffuse intravascular coagulation to be involved in the COVID-19 pathophysiology [7, 18]. Severe injury leads to activation and, ultimately, depletion of coagulation factors. Increased vigilance over the performance of the patients’ coagulative function is to be recommended in polytraumatized patients or patients who receive multiple transfusions for trauma while being infected with SARS-nCoV-2. The viral illness may lead to the consumption of coagulation factors beyond the time of achieving surgical and biochemical hemorrhage control for the patients’ injury, translating into a need for a more extended period of vigilance over the patients’ coagulation parameters than would be otherwise expected for an injured patient.

Patients who leave the hospital after prolonged ICU stays recovering from COVID-19 have decreased strength, balance, and increased osteopenia. This puts patients at risk of more severe injury with falls and minor trauma. Providers involved in the discharge of these patients should educate patients about the implications of prolonged hospitalization and make efforts to prevent injuries during the rehabilitation phase. Physical therapy can help reduce fall risk, increase stability and muscle strength, and reduce osteopenia.

10.6 Conclusion

The 2020 COVID-19 pandemic affects many facets of society and healthcare provision, including the care available to trauma patients. Hospitals and providers should make efforts to anticipate the altered epidemiology of trauma that results mostly from societal measures to limit the spread of the virus.
The presence of a pandemic poses specific challenges to healthcare systems necessitating adaptation of routines and protocols to protect healthcare workers and contain viral spread within healthcare facilities. Separating patient flows upon hospital admissions, even for urgent admissions, is of utmost importance. This implies changes are needed to routine workflow in every phase of care, from the prehospital to the hospital phase and to discharge.

Healthcare providers involved in the care of trauma patients should be educated on the pathophysiology of COVID-19 and potential complex interactions on various organ systems. Some pathophysiological processes associated with SARS-nCoV-2 may increase the disease burden of trauma in (poly)traumatized patients.

More research and more data are needed to draw conclusions on the epidemiology of trauma, the interplay of COVID-19, and pathophysiologic processes in the traumatized patient and to design optimal guidelines for preparing the healthcare system to deal with different patient flows as well as for direct patient care.

10.7 Summary Points

- The number of trauma patients presenting to the hospital has been affected by the COVID-19 pandemic.
- Trauma services should presume that all patients are positive for SARS-nCoV-2 until they have been adequately triaged.
- Triage is based on patient symptoms, radiology, and RT-PCR testing.
- COVID-19 is a multisystem disorder and may exacerbate the effects of polytrauma.
- Renal and cardiac dysfunction should be monitored perioperatively.
- Hypoxia and hypercarbia may not be well tolerated in acidotic trauma patients.
- COVID-19 patients may be at risk of pro-thrombotic complications.

References

1. European Transportation Safety Council, Brussels, Belgium: COVID-19: Huge drop in traffic in Europe, but impact on road deaths unclear. ePub 7 April 2020.
2. Governors Highway Safety Association, Washington District of Columbia, United States of America: Traffic Safety Community Urges Safer Driving During Coronavirus Pandemic. ePub 16 April 2020.
3. United Nations Women, New York City, United States of America. COVID-19 and ending violence against women and girls. ePub May 2020.
4. American College of Surgeons Committee on Trauma. Maintaining trauma center access and care during the COVID-19 pandemic: guidance document for trauma directors. https://www.facs.org/quality-programs/trauma/maintaining-access. Accessed on 20.09.2020.
5. Bank M, O’Neill P, Prince J, Simon R, Teperman S, Winchell R. Early report from the Greater New York Chapter of the American College of Surgeons Committee on Trauma on the COVID-19 crisis. https://www.facs.org/-/media/files/covid19/nyc_chapter_acs_cot_covid19_crisis.ashx. Accessed on 20.09.2020.
6. Yang B, Barnard L, Emert J, Drucker C, Schwarz L, Counts C, et al. Clinical characteristics of patients with coronavirus disease 2019 (COVID-19) receiving emergency medical services in King County, Washington. JAMA Netw Open. 2020;3(7):e2014549.

7. Zarei F, Reza J, Seifidbakht S, Iranpour P, Haghjhi R. Aspiration pneumonia or COVID-19 infection: a diagnostic challenge. Acad Radiol. 2020;27(7):P1046.

8. Oran DP, Topol EJ. Prevalence of asymptomatic SARS-CoV-2 Infection; a narrative review. Ann Intern Med. 2020; https://doi.org/10.7326/M20-3012.

9. Samsami M, Bagherpour J, Nematihonar B, Tahmasbi H. COVID-19 pneumonia in asymptomatic trauma patients; report of 8 cases. Arch Acad Emerg Med. 2020;8(1):e46.

10. https://www.covid19treatmentguidelines.nih.gov/critical-care/laboratory-diagnosis.

11. Coimbra R, Edwards S, Kurihara H, Bass GA, Balogh Z, Tilsed J. European Society of Trauma and Emergency Surgery (ESTES) recommendations for trauma and emergency surgery preparation during times of COVID-19 infection. Eur J Trauma Emerg Surg. 2020;17:1–6.

12. Zaim S, Chong J, Sankaranarayanan V, Harky A. COVID-19 and multiorgan response. Curr Probl Cardiol. 2020;00:100618.

13. Gong Y, Cao X, Mei W, Wang J, Shen L, Wang S, et al. Anesthesia considerations and infection precautions for trauma and acute care cases during the coronavirus disease 2019 pandemic: recommendations from a Task Force of the Chinese Society of Anesthesiology. Anesth Analg. 2020;131(2):326–34.

14. Dexter F, Parra M, Brown J, Loftus R. Perioperative COVID-19 defense: an evidence based approach for optimization of infection control and operating room management. Anesth Analg. 2020;131(7):37–42.

15. COVIDSurg Collaborators. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. Lancet. 2020;396(10243):27–38.

16. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(2020):497–506.

17. Maldonado E, Tao D, Mackey K. Antithrombotic strategies in COVID-19 disease: a systematic review. J Gen Intern Med. 2020;17:1–9. ePub ahead of print.

18. Abou-Ismail MY, Diamond A, Kapoor S, Arafah Y, Nayak L. The hypercoagulable state in COVID-19: incidence, pathophysiology and management. Thromb Res. 2020;194:101–15.