

Comment & Opinion

Guideline for diagnosis and treatment of spine trauma in the epidemic of COVID-19

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ABSTRACT

Outbreak of COVID-19 is ongoing all over the world. Spine trauma is one of the most common types of trauma and will probably be encountered during the fight against COVID-19 and resumption of work and production. Patients with unstable spine fractures or continuous deterioration of neurological function require emergency surgery. The COVID-19 epidemic has brought tremendous challenges to the diagnosis and treatment of such patients. To coordinate the diagnosis and treatment of infectious disease prevention and spine trauma so as to formulate a rigorous diagnosis and treatment plan and to reduce the disability and mortality of the disease, multidisciplinary collaboration is needed. This expert consensus is formulated in order to (1) prevent and control the epidemic, (2) diagnose and treat patients with spine trauma reasonably, and (3) reduce the risk of cross-infection between patients and medical personnel during the treatment.

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Introduction

Since December 2019, a series of patients with COVID-19 successively emerged in Wuhan, which has been included in the Class B infectious diseases stipulated in the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases and managed as a Class A infectious disease.^{1,2} Compared with severe acute respiratory syndrome (SARS) coronavirus, COVID-19 has a lower lethality,^{3,4} but it is more infectious and pathogenic. So far, more than 83,046 cases of COVID-19 have been

diagnosed nationwide, including more than 3000 healthcare workers in Hubei Province, China, far exceeding the number of SARS infections.^{5,6} Furthermore, a total of 7,036,623 cases of COVID-19 have been confirmed globally until 8 June, 2020 according to statistics from Johns Hopkins University. COVID-19 is highly contagious, and the source of infection can be COVID-19 patients and the asymptomatic. The main routes of transmission of 2019-nCoV are respiratory droplets, close contact and perhaps aerosol transmission which means long-term exposure to high concentrations of aerosols in a relatively closed environment.^{1–4,7–9}

Spinal cord injury (SCI) is a catastrophic injury and the most common complication of spine trauma that can lead to severe disability throughout life, placing a huge burden on patients, families and society.^{10–12} The epidemic of COVID-19 has brought great challenges to medical intervention of spine trauma, such as pre-hospital care, emergency diagnosis and treatment, surgical strategy, anesthesia, as well as peri- and postoperative management. To

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reduce the risk of cross-infection among patients and healthcare workers and improve the prognosis of patients, multidisciplinary collaboration is needed to coordinate the diagnosis and treatment plan of COVID-19 and spine trauma. Therefore, we formulate a guideline for emergency diagnosis and treatment of spine trauma during COVID-19 epidemic. This guideline is recommended as a reference for emergency diagnosis and treatment of spine trauma during COVID-19 epidemic.

Establishment of a multidisciplinary team of trauma and infection

Spine trauma is a life-threatening injury resulted from high-energy crash¹¹ and may be combined with craniocerebral trauma, thoracic trauma or thoracic & abdominal injuries. Therefore, a multidisciplinary trauma team including infection department needs to be established in COVID-19-designated hospitals, usually consisting related departments of emergency, infection, pneumology, traumatology, orthopedics, general surgery, neurosurgery, intensive medicine, anesthesia, cardiothoracic surgery, radiology, etc., and the core members should consist of senior physicians and infectious disease prevention specialists who have received professional training in advanced trauma life support and other first aid. The team needs to diagnose and treat spine trauma patients with suspected or confirmed COVID-19, and provide instructions to strengthen pre-hospital and intra-hospital prevention and control of 2019-nCoV infections according to the relevant documents and guidelines of the National Health Commission.^{1,2,7–9}

If possible, a multidisciplinary team of SCI should be established in COVID-19-designated hospitals in advance since SCI is a common but life-threatening complication among trauma patients. The SCI team should include specialists from orthopedics, emergency surgery, radiology, anesthesia, intensive care unit (ICU), rehabilitation, neurosurgery, respiratory medicine, neurology, traditional Chinese medicine, etc., using tele-medicine to obtain the patient's condition in advance and coordinate the following work. The core members should be the senior surgeons who have been received professional training on SCI.

Pre-hospital first aid

On-site first aid

The initial treatment of patients with spine trauma is similar with any other traumatic injuries. To identify and evaluate the life-threatening injuries that require emergent intervention is the priority and of significance.¹¹ After arriving at the scene, initial physical examination and systematic evaluation of the injured should be obtained by the first responders; emergent treatments like hemostasis, bandage, fixation and transportation should be implemented quickly to save lives. For patients with suspicious spine trauma,^{11,13} that is, spinal pain with neurological dysfunction such as extremity weakness or paresthesia, bowel and bladder dysfunction, and paraplegia or quadriplegia, spine immobilization should be conducted on the spot. All medical personnel should take level 2 protective measures strictly according to the relevant documents and guidelines of the National Health Commission^{1,2,7} during first aid.

Spine trauma patients should be moved by at least three people. Moreover during the transfer, the measures of cervical collar protection, manual stabilization of the cervical spine, flat positioning, and log-roll turning should be performed to protect the spine and avoid secondary insults.¹¹ Meanwhile, telehealth can be adopted to inform personnel at the emergency room or the team to get prepared and obtain some consultation advice in advance. Patients

should be quickly transferred to nearby hospitals with isolation and protection conditions, by which the risk of secondary spinal cord insults caused by instability can be largely reduced. Once on the ambulance, a series of treatment measures should be implemented, including establishing a venous channel, monitoring vital signs, oxygen therapy and rehydration.

Transportation to hospital

In principle, the injured patients should be transported to the nearest hospital capable of diagnosis and treatment and equipped with isolation and protection rooms. It should be noted that when the ambulance is exposed to high concentration aerosol for a long time in a relatively closed environment, the virus may be transmitted by aerosol.^{7,9} Therefore, prevention must be taken strictly (at least level 2 protective measures) while opening windows for ventilation, during which the patient must keep warm. Patients should be sent to the COVID-19-designated hospital for treatment unless they have been confirmed to have no COVID-19. It is necessary to inform the emergency room of the receiving hospital or the fever clinic as soon as possible for a better preparation and protection. After receiving a suspected or confirmed COVID-19 patient, immediate thorough sterilization of the vehicle is necessary.⁹ Immobilization of the spine during transfer and transportation should be especially noted.¹³ For patients with cervical SCI, attention should be paid to the respiratory function and blood oxygen saturation.^{7,11,14}

Treatment in emergency room

Protection of medical staff in the emergency room and the fever clinic

All medical staff in the emergency room and the fever clinic with possible contacts to suspected or diagnosed COVID-19 patients should take level 2 protective measures.⁷ If the patient is unconscious, or his/her family members cannot provide the epidemiological history, the suspected cases of COVID-19 shall be treated as confirmed cases. In the epidemic area, all spine trauma patients should be treated as suspected COVID-19 cases. The consulting room shall be warded with sufficient protective & rescue equipment, and the medical equipment shall be disinfected and replaced timely according to the standard process.

Indications of emergent surgery

When the patients arrive at the hospital, the prepared infection and trauma multidisciplinary team should inquire the medical history as soon as possible, check the vital signs, oxygen saturation, etc., and immediately identify life-threatening injuries that require emergent intervention. Moreover, never ignore the importance of spinal immobilization. In principle, for suspected or confirmed COVID-19 cases without indications, emergent surgical treatment should be avoided.

Diagnosis of COVID-19

If possible, the hospital should take sputum, nasopharynx swab or blood samples, using real-time fluorescent reverse transcription-polymerase chain reaction to detect viral nucleic acid or gene sequencing to make final diagnosis. According to the guidelines,⁷ the infectious-disease specialist should make the diagnosis of suspected or confirmed COVID-19. If the patients sent to the emergency room are preliminarily assessed as suspected COVID-19, they should be transferred immediately to the fever clinic to complete a chest CT

scan and other relevant examinations.^{4,7} All patients admitted during the epidemic period of COVID-19 should be screened by the 2019-nCoV specific antibodies test and a chest CT scan. Sometime, it is difficult to diagnose or identify asymptomatic or nucleic acid negative patients, so appropriate protective measures should be taken to all patients during the epidemic.

It should be noted that most patients with spine trauma are associated with traumatic wet lung, which should be differentiated from the pulmonary imaging findings of COVID-19. The development of traumatic wet lung is progressive in 12–24 h after injury. The lung parenchyma injury and alveolar hemothorax can be found in CT scan, but there is no interstitial lung injury in patients with COVID-19, while ground glass opacity changes are found in the bilateral lobes in COVID-19.^{3,4} At the same time, no obvious fever symptoms are present in patients with simple traumatic wet lung.

Management of patients with spine trauma

While the infection-trauma multidisciplinary team is taking actions, spine surgeons should evaluate the spine and the function of the spinal cord as soon as possible. The main indications of emergent surgery include unstable spinal fracture associated with/without SCI – American Spinal Injury Association Impairment Scale (AIS) grade C or below and progressive neurological aggravation in mild or common COVID-19 patients; severe COVID-19 is a relatively contraindication. If surgery cannot be performed, immobilization of the spine should be maintained through braces. Patients with critical COVID-19 or those who are intolerant to operation or anesthesia are absolute contraindication.^{7,15} It is recommended that the operation should be performed as early as possible within 8–24 h after injury.

- (1) Regarding simple spine fracture with or without SCI, no other life-threatening traumas, stable hemodynamics and sound respiratory function, X-ray and CT scan of the spine should be performed immediately to identify the fracture and dislocation. For patients who need early surgery, magnetic resonance imaging examination of the spine should be performed to evaluate the SCI and guide the preparation of the operation.^{13,16} Stable spine fracture without neurological injury may require no urgent intervention¹³ and COVID-19 should be treated in priority, but neurological function shall be closely monitored. If imaging and clinical manifestations suggest SCI, the average arterial pressure should be maintained above 85 mmHg.^{17,18} If there is no contraindication, emergent surgery should be arranged for patients with unstable spine fracture with or without SCI (AIS grade C or below) and progressive aggravation of neurological function. However, in patients with severe or critical COVID-19, the main purpose is to save lives. Anyway stability of the spine should be maintained.
- (2) For spine trauma combined with multiple injuries, life-threatening injuries should be handled firstly and then the spine. If the combined injury is stable and the patients were estimated able to tolerate the operation by relevant specialists, emergency operation shall be arranged as soon as possible.^{13,17,18,21} If the patient is unstable, surgical treatment of spine and SCI shall be carried out soon after multidisciplinary consultation and related treatments. If emergent operation is needed, the preoperative preparation should be finished timely.
- (3) For spine trauma excluded of COVID-19 and emergent surgery by the multidisciplinary team of SCI, patients can be admitted to the general ward in a single room to minimize the number of family caregivers; severe or critical cases can

be admitted to the ICU as soon as possible.^{7,11} The suspected cases of COVID-19 can be treated by single room isolation, and the confirmed cases be treated in multiple-bed rooms (2–3 confirmed patients a room in Wuhan practice) (Fig. 1).⁷

- (4) Although guidelines suggest a 24-h infusion of high-dose methylprednisolone be offered to adult patients within 8 h as a treatment option for acute SCI,^{13,20} this is not recommended for any types of COVID-19 patients with SCI, in case of related immunosuppression, side effects and other related risks or aggravation of COVID-19. However, for patients with progressive deterioration of oxygenation index, rapid aggravation of chest CT scan and hyperactivation of inflammatory response, a small dose of methylprednisolone can be used in a short period. It is suggested that the dose of methylprednisolone should not exceed 1–2 mg/kg/day.⁷

Preoperative protection for emergent operation

Patient transport

Since the results of nucleic acid and etiology detection are unable to get in emergent conditions, all emergency patients should be protected as suspected or confirmed COVID-19 patients. Patients should be transferred strictly according to National Health Commission of the People's Republic of China. According to transport plan for novel coronavirus infection cases (Trial),⁹ all medical personnel should take level 2 protective measures, using the special transfer vehicle with disposable sheets to lead patients to transfer to the negative pressure operation room through a special channel and lift. During transfer, patients should wear surgical masks or N95 masks to prevent cross-infection.^{7,9} The operating room has been set different areas to reduce cross-infection according to the guideline.^{1,8,15}

Personnel protection in operating room

Level 3 protective measures are required in the operating room. The operating room must be in a state of negative pressure (–5 Pa) before operation. The buffer room should be closed, and the number of the equipment should be minimized in the operating room. The door of the operating room should be marked with 2019-nCoV. When there is a risk of aerosol infection, level 3 protective measures should be carried out.¹⁵ The surgeons, hand washing nurses and anesthesiologists involved in the operation should take level 3 protective measures,¹⁵ while patrol nurses can take level 2 protective measures.

Minimize the number of staff involved in the operating room. Visitors should be prohibited and medical personnel should not enter or leave the operating room at will, so as to avoid interrupting the negative pressure of the operating room. Medical staff wearing protective clothing in the operating room is forbidden to leave the operating room. If fluoroscopy is required during the operation, they should wear lead clothing in advance and take self-protection measures to reduce the radiation intake.

Patients with non-generalized anesthesia should wear surgical masks throughout the operation. For patients under general anesthesia, a breathing filter should be installed between the anesthetic mask and the respiration loop, and a breathing filter should be installed at the inhalation and exhalation ends of the anesthesia machine, respectively.^{6,15}

After operation, the medical staff should disinfect their hands first, and then remove the disposable medical protective equipment layer by layer according to corresponding procedures, discard them in the double-layer yellow medical waste bag marked with

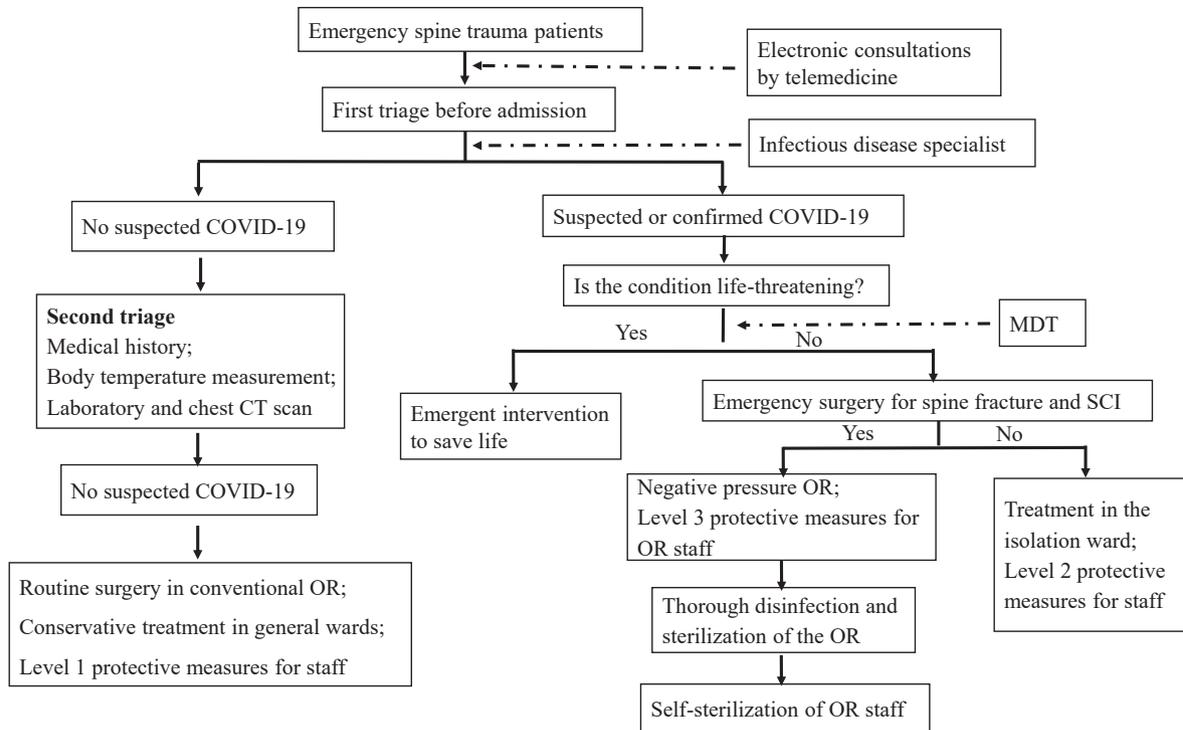


Fig. 1. Flow chart of diagnosis and treatment guidelines for spine trauma patients with confirmed or suspected COVID-19. OR: operation room.

2019-nCoV. It is necessary to wash hands with flowing water after removing protective gowns and gloves for at least 2 min.¹

Surgery treatment

Emergent operation plan

The operation plan should fully consider the complex situation of spine trauma combined with COVID-19, and be customized for the specific patient. The preoperative consent should inform the COVID-19 patients that mild or common COVID-19 type may aggravate into severe and critical one. According to the injury type, stability, neurological function, medical equipment and technical conditions, the purpose of operation should be completed in a single approach as far as possible.^{11,13} Goals of surgical management in the patient with SCI are to decompress the spinal cord, restore the sequence of spinal column, stabilize the spine, and prevent further neurologic deficits. When the patient's condition is stable, necessity of second operation should be considered. The effects of general anesthesia time, trauma, hemorrhage and cerebrospinal fluid leakage on patients with COVID-19 need to be reduced.

For patients with COVID-19, the posterior approach is preferred. The anterior approach is not recommended for that tracheotomy may be required after exacerbation of COVID-19.^{11,14} Later, if necessary, anterior fusion and other related surgeries may be done. Minimize the surgical wound and try to use disposable surgical instruments.⁷ For most patients, posterior laminectomy is feasible. For some patient with spinal cord compartment syndrome or spinal cord intramedullary hypertension accompanied by extensive edema in the spinal cord,^{13,21–23} extensive laminectomy, durotomy and duroplasty decompression with preservation of arachnoid under microscope are effective.^{13,23,24} If hematoma or softened necrotic region in the spinal cord is identified, myelotomy under microscope may be an appropriate choice. Close suture should be requested during duroplasty to minimize the incidence of cerebrospinal fluid leakage.¹⁸

Prevention during operation

When using the electric knife, ultrasonic bone knife, grinding drill and other equipment, the smoke generated should be removed by an aspirator timely to prevent the aerosol formed by the smoke from infecting the medical staff or polluting the instruments in the operating room. During operation, normal saline for flushing should be reduced as much as possible; splashing of the patient's body fluid should be avoided; and residue of the fluid should be reduced as much as possible to prevent pollution of the surrounding environment. The operators need to cooperate closely to prevent acupuncture and sharp instrument injury and reduce the occurrence of occupational exposure.¹⁵

Postoperative management

Operating room management

The high-efficiency filter screen in the negative pressure operating room shall be replaced timely when operation is finished; closed thorough disinfection and sterilization of the operating room must be performed by spraying peracetic acid or hydrogen peroxide for more than 2 h; and the laminar flow and air supply shall be closed. The sampling of the object surface and air in the operation room must be tested by the hospital infection management department after the disinfection process. The next operation can be continued only after qualified monitoring results.¹ Surgical instruments that have been directly exposed to the patient's body fluid should be immediately scrubbed with 1000–2000 mg/L chlorine-containing disinfectant, and then classified into double-layer yellow medical waste bags, labeled with 2019-nCoV, and immediately informed the disinfection and supply center to take them away. Medical observation must be carried out for two weeks for medical staffs involved in the operation of patients with suspected or confirmed COVID-19. If the nucleic acid result of the patient is negative after operation, and the infection of 2019-nCoV has been

excluded by experts from the hospital infection management department, the operation participants can stop the isolation.⁷

Postoperative patient management

Although preoperative chest CT scan is an important basis for clinical diagnosis of COVID-19,⁴ patients with spine trauma may have lung injury, so nucleic acid detection or virus sequencing should be done as soon as possible after operation to confirm whether the patient has COVID-19 or not, and then corresponding treatment can be carried out. In addition to symptomatic and supportive treatment, complications, basic diseases, secondary infection and thrombosis should also be controlled and treated; furthermore, early rehabilitation^{13,25} should be done to promote the recovery of neurological function and enable patients to return to society as soon as possible.

The body temperature of patients should be monitored at least three times a day after operation. For patients with COVID-19, the wound infection should not be judged only by the results of blood tests and body temperature.²⁶ Patients with high cervical SCI often have abnormal temperature regulation, which may cause fever. Pay attention to whether it is caused by the wound itself or infection of the wound after operation, and pay special attention to distinguish it from the fever caused by COVID-19. After spine surgery, the infection and fever should be distinguished from the wound condition, blood test, bacterial culture and even pathological examination. Pay attention to whether there is redness, swelling, skin temperature rise and secretion in the operation area or not. The blood test often shows the rise of leukocyte, erythrocyte sedimentation rate and C-reactive protein, which can be used as the main identification to exclude the infection of 2019-nCoV.²⁶ At the same time, it is necessary to continue to strengthen the monitoring and protection of patients and family caregivers, and pay attention to the possibility of positive viral etiology test results in patients recovered from COVID-19.

Rehabilitation training should be carried out as early as possible after operation,²⁵ especially for respiratory function rehabilitation, which can be carried out in half lying or sitting position under the protection of brace. Active cough and expectoration or with the assistance of diaphragm pacemaker, expectoration machine should be encouraged. If necessary, fiberbronchoscope should be used to remove sputum and bronchial secretion, preventing hypostatic pneumonia. Cough or other symptoms like COVID-19 indicate immediate laboratory, chest CT scan and virus etiology examinations be conducted to eliminate the possibility of 2019-nCoV infection.⁷ The novel coronavirus infection prevention and control technical guidelines (First Edition) in medical institutions should be strictly followed during wound dressing change.¹ The waste dressing should be strictly placed in double yellow medical waste bags labeled 2019-nCoV and placed separately. When the patient's nucleic acid test of 2019-nCoV shows negative twice in a row after confirmed by the infection expert, he/she can be transferred to the general ward.^{1,7}

Respiratory muscles may be paralyzed in patients with cervical SCI, so respiratory support should be strengthened as early as possible. For patients with SCI at or above C₄, immediate tracheotomy is recommended. For patients with SCI at or below C₄, close observation of the patient's breathing should be made and there should be preparation for tracheotomy at any time.^{7,11,14} When the obstruction of respiratory tract is cleaned, and the partial pressure of arterial oxygen is lower than 50 mmHg or the partial pressure of carbon dioxide is higher than 50 mmHg, respiratory myasthenia should be diagnosed and endotracheal mechanical ventilation should be performed as soon as possible. Early tracheotomy is recommended for patients with AIS grade A or B SCI at the C₄–C₆

level who are combined with any of the following conditions: chest trauma, lung disease, cervical surgery and mechanical ventilation for more than 7 days, or injury severity score > 32.^{13,27}

For patients with spine trauma, hemorrhage is dangerous and prevention of deep vein thrombosis should be carried out as early as possible.^{11,19} Pulmonary embolism is a serious complication of SCI. Acute pulmonary embolism is a serious life-threatening disease, which needs to be differentiated from critical type of COVID-19. Preventive anticoagulant therapy, lower extremity elastic socks, early active and passive functional exercise are effective means to prevent deep vein thrombosis. However, referring to Prevention and Control Protocols of Novel Coronavirus Pneumonia (Pilot version 7 modified),⁷ disseminated intravascular coagulation and multiple organ failure will occur in patients with critical COVID-19. Therefore, we suggest not offering anticoagulant therapy to adult patient with severe or critical COVID-19.⁴

After surgical stabilization, patients with cervical and high thoracic SCI should be treated in a monitored setting such as ICU. We should actively prevent the related complications. It is necessary to monitor the patient's electrolyte and correct hyponatremia. Although patients with multiple injuries are likely to develop hemorrhagic shock,¹¹ patients with SCI at or above T₆ may have neurogenic shock, especially those with cervical SCI. After fluid resuscitation, vasoactive drugs are used to maintain hemodynamic stability. The mean arterial pressure should be maintained above 85 mmHg^{11,13,17} in 7 days after operation to ensure sufficient arterial perfusion pressure in the spinal cord.

The rehabilitation therapist of the multidisciplinary team of SCI should provide intervene early, during the stay in ICU or orthopedic department wards.² If the patient's condition is stable, he/she should be transferred to the rehabilitation department to continue rehabilitation exercises and reduce complications. If necessary, nerve transposition should be performed to improve bowel and bladder dysfunctions.²⁸

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Ethical Statement

Not applicable.

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Declaration of Competing Interest

No conflict of interest exists in the submission of this manuscript.

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