Rapid sequence intubation for adults outside the operating room

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AIRWAY MANAGEMENT FOR PATIENTS WITH COVID-19

In patients with novel coronavirus (COVID-19 or nCoV) disease, there is a high risk of aerosol spread of the virus during airway management procedures. To avoid such spread, certain practices used in standard rapid sequence intubation (RSI) must be modified. Techniques for improving patient care and minimizing infectious risks to care providers and spread of the virus during emergency intubation are summarized in the following table (table 1) and discussed in greater detail separately. (See "Safety in the operating room", section on 'COVID-19' and "Coronavirus disease 2019 (COVID-19): Critical care issues", section on 'The decision to intubate'.)

INTRODUCTION

Clinicians frequently use rapid sequence intubation (RSI) to secure the airway in an acutely unstable patient. RSI involves the administration of an induction agent followed quickly by a neuromuscular blocking agent to create optimal intubating conditions and minimize the time the airway is unprotected. RSI presupposes the patient is at risk for aspiration of stomach contents and incorporates medications and techniques to minimize this risk. Use of RSI also helps to mitigate the potential adverse effects of airway manipulation.

This topic reviews the central concepts and techniques needed to perform RSI in adults in the emergency setting outside the operating room. RSI for anesthesia, RSI in children, the medications

used for emergency RSI, and other subjects related to emergency airway management are reviewed separately:

- For medications used for RSI in adults: (see "Induction agents for rapid sequence intubation in adults outside the operating room" and "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room")
- For RSI in children: (see "Rapid sequence intubation (RSI) outside the operating room in children: Approach" and "Rapid sequence intubation (RSI) outside of the operating room in children: Medications for sedation and paralysis")
- For basic and advanced airway management: (see "Basic airway management in adults" and "Extraglottic devices for emergency airway management in adults" and "Direct laryngoscopy and endotracheal intubation in adults" and "Video laryngoscopes and optical stylets for airway management for anesthesia in adults")

DEFINITION

RSI is the virtually simultaneous administration of an induction agent and a neuromuscular blocking agent to induce unconsciousness and paralysis to facilitate rapid tracheal intubation. The technique is designed to maximize the likelihood of successful intubation and to minimize the risk of aspiration. It is essential that maximal preoxygenation and hemodynamic optimization precede drug administration. (See "Induction agents for rapid sequence intubation in adults outside the operating room" and "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room".)

Preoxygenation is a crucial step of RSI that creates a large intrapulmonary reservoir of oxygen that allows patients to tolerate a period of apnea without clinically significant oxygen desaturation. For patients at high risk for aspiration, bag-mask ventilation is avoided during the interval between drug administration and tracheal tube placement, thereby minimizing gastric insufflation and reducing the risk of aspiration. RSI has been shown to be associated with increased first pass success (ie, successful tracheal tube placement on first attempt) and reduced incidence of complications [1,2]. However, since the induction agent is pushed rapidly, critically ill patients are at risk for the development of hypotension. When circumstances allow, such risk can be mitigated by the choice of induction medication and by optimizing cardiovascular status with crystalloids, blood products, vasopressors, or inotropes as appropriate prior to RSI. (See 'Preintubation optimization' below.)

INDICATIONS

RSI is the most common emergency method for securing control of the airway in critically ill patients not anticipated to be difficult intubations [3-9]. Many studies have demonstrated the benefits of RSI in the critically ill patient, with improved first pass success and reduced incidence of complications [1,2,10]. RSI may also be the preferred approach in a patient with an anatomically difficult airway if the intubator is confident that gas exchange can be maintained, either by successful intubation or by use of a rescue device. In an observational registry study of emergency department intubations, 80 percent of predicted difficult airways were managed with RSI using a videolaryngoscope with a high first pass success rate [11]. When performing RSI in a patient with an airway predicted to be difficult, the clinician must have immediate access to the equipment necessary to restore oxygenation. Such equipment generally includes a bag and mask device, extraglottic airway, and tools for a surgical airway. (See "Approach to the anatomically difficult airway in adults outside the operating room" and "Basic airway management in adults" and "Extraglottic devices for emergency airway management in adults" and "Emergency cricothyrotomy (cricothyroidotomy)".)

CONTRAINDICATIONS AND PRECAUTIONS

Contraindications to RSI are relative. The most important contraindication to RSI is anticipation of difficult or impossible rescue oxygenation. In patients who cannot tolerate apnea (eg, profound hypoxemia or metabolic acidosis is present), neuromuscular blockade may be undesirable and an "awake" intubation approach (ie, use of topical anesthesia and light sedation) preferred in order to minimize the likelihood of precipitous deterioration.

Medications for induction and neuromuscular blockade should be selected to achieve airway management goals while minimizing side effects. Particular drugs used for RSI are discussed in detail separately. (See "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room" and "Induction agents for rapid sequence intubation in adults outside the operating room".)

DESCRIPTION OF THE TECHNIQUE

The updated "Seven P's of RSI" is a mnemonic that outlines the key steps of RSI planning and performance (table 2) [12-14]:

- Preparation
- Preoxygenation
- Preintubation optimization
- Paralysis with induction

- Positioning
- Placement with proof
- Postintubation management

Preparation — Preparation includes assessing the patient's airway for potential difficulty, developing an airway management plan (including a backup plan), and assembling all necessary personnel, equipment, and medications. The following table summarizes these steps (table 3). A detailed discussion of the steps needed to prepare for intubation is provided separately. (See "Direct laryngoscopy and endotracheal intubation in adults", section on 'Preparation'.)

Once the need for intubation is determined, and prior to committing to RSI as the method of intubation, the clinician assesses the patient for anatomic features and clinical findings that indicate the patient may be difficult to intubate or to ventilate using a bag-mask, or in whom it may be difficult to use a rescue airway, such as an extraglottic device. (See "Approach to the anatomically difficult airway in adults outside the operating room".)

Although the presence of markers for difficult intubation or difficult bag-mask ventilation is not an absolute contraindication to RSI, if such features are identified, alternatives to RSI may be preferred. If the clinician chooses to proceed with RSI in the presence of such markers, a complete backup plan should be in place and all necessary resources needed to enact that plan available at the bedside. In addition, an assessment must be performed for the presence of any physiologic derangements that increase the risk of cardiovascular collapse after the administration of RSI medications and transition to positive pressure ventilation. Hypoxemia and hypotension must be recognized and, if possible, corrected before RSI medications are given. Right ventricular failure and severe metabolic acidosis are less common conditions, but they too can cause rapid physiologic deterioration with RSI [15]. Patients with profound metabolic acidosis may experience a precipitous deterioration even during brief periods of apnea as compensatory elimination of carbon dioxide is halted. Severe asthma, active myocardial ischemia, tachydysrhythmias, and all forms of shock require a tailored approach that results in successful tube placement and minimal risk of hypoxic insult or circulatory collapse. (See 'Preintubation optimization' below.)

If an anatomically difficult airway is predicted, rapid desaturation is anticipated, or severe hemodynamic compromise is identified, RSI may not be the best approach to achieve airway control. Instead, an "awake technique" in which the patient is intubated with topical anesthesia, and sometimes light sedation, rather than unconsciousness and paralysis, may be preferred [16,17]. The benefit of the awake approach is that the patient continues spontaneous ventilation and thereby the dangers of apnea and hemodynamic compromise associated with RSI medications are avoided. However, awake intubation has potential drawbacks. It may be poorly tolerated by the patient,

requires adequate time for topical anesthesia, secretion control and (often) sedation, and takes longer to achieve intubation.

Choosing between RSI and awake intubation can be difficult, and the clinician must carefully consider the pros and cons of each approach in the particular patient, including available equipment and pharmacologic agents, to determine the best course. Discussions of how to determine the need for intubation and how to identify airways that are potentially difficult to intubate or ventilate are found separately. (See "The decision to intubate" and "Approach to the anatomically difficult airway in adults outside the operating room".)

Prior to proceeding with RSI, at least one, but preferably two, functioning intravenous (IV) lines should be in place, as should cardiac and blood pressure monitors, pulse oximetry, and capnography. (See "Pulse oximetry" and "Carbon dioxide monitoring (capnography)".)

Patients undergoing airway management should be in an appropriate clinical area where all necessary airway and resuscitation equipment are available. The airway manager should have easy access to the head of the bed, and should adjust the height of the bed and position of the patient to facilitate intubation. The equipment and steps necessary to prepare for and perform tracheal intubation are reviewed separately. (See "Direct laryngoscopy and endotracheal intubation in adults" and "Video laryngoscopes and optical stylets for airway management for anesthesia in adults", section on 'Videolaryngoscopy'.)

The clinician selects the induction and neuromuscular blocking agents (NMBAs) to be used and determines the doses. Allergies and potential contraindications should be considered carefully. The medications to be used are drawn up into labeled syringes, and standard closed-loop communication protocols should be used to ensure proper dosing. (See "Induction agents for rapid sequence intubation in adults outside the operating room" and "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room".)

The goal of preparation is to maximize the chances for successful intubation on the first attempt. Studies suggest that the risk of an adverse event during emergency tracheal intubation (eg, aspiration, hypotension, esophageal intubation) increases significantly with the number of attempts [18,19]. An observational emergency department (ED) study of 1828 intubations reported that 14 percent of patients intubated on the first pass experienced an adverse event compared to 47 percent of those intubated on the second attempt [18].

Preoxygenation

General guidelines and common scenarios — Preoxygenation increases the safety of RSI. Any patient requiring urgent tracheal intubation ideally should be preoxygenated for a minimum of three

minutes using oxygen delivered at the highest flow rate available (ideally at flush rate: 40 to 70 liters per minute [LPM]) [20,21]. Most commonly, a nonrebreather mask or a bag-valve mask is used. Using the flush rate (wide open) should be encouraged and is advantageous compared with the "standard" 10 to 14 LPM commonly used with nonrebreather masks in other circumstances.

Preoxygenation replaces the nitrogen in the gas-exchanging portions of the lung (functional residual capacity [FRC]) with oxygen, thereby creating a large oxygen reservoir. This significantly delays oxygen desaturation during the apneic period of RSI [22,23]. Common conditions that cause oxygen desaturation or exacerbate hypoxemia following RSI and interventions to help prevent or manage them are summarized in the following table (table 4).

Researchers have characterized the expected time to desaturation below 90 percent after apnea is induced in properly preoxygenated patients of various ages and comorbid conditions (figure 1) [24]:

- Healthy 70-kg male: 6 to 8 minutes
- Young children (10 kg): <4 minutes
- Adults with chronic illness or obesity: <3 minutes
- Women at near full-term pregnancy: <3 minutes

Critically ill patients in the ED or intensive care unit (ICU) often desaturate even more quickly, if not immediately.

The important concept is that preoxygenation provides a longer period before clinically significant desaturation, regardless of the patient's condition, age, and body habitus. Continuous monitoring of oxyhemoglobin saturation by pulse oximetry is essential during RSI. This task should be assigned to an individual who can reliably and regularly track and report the information without other tasks or distractions. When assessing oxygen saturation, remember that pulse oximetry readings obtained with a finger probe may lag behind the central arterial circulation, particularly in critically ill patients [20,25].

There are multiple ways to perform preoxygenation in the critically ill depending on the scenario:

- **Inadequate spontaneous ventilation** – In the patient with inadequate spontaneous ventilation, preoxygenation should be performed using gentle positive pressure ventilation with a bag-valve mask (BVM) at flush-flow rate with a synchronous bag-assist technique (ie, clinician delivers ventilations simultaneously with the patient's inhalation). It is important to ventilate these patients with pressures less than 20 cm H_2O to avoid gastric insufflation. However, in patients with high intrinsic airway pressures (eg, morbid obesity, severe asthma), greater force may be required to ventilate. In such patients, we recommend that cricoid pressure be applied during bag-mask

ventilation, as this compresses the cervical esophagus, thereby minimizing gastric insufflation and reducing the risk of aspiration [26,27]. (See 'Cricoid pressure (Sellick maneuver)' below.)

- **Adequate spontaneous ventilation and cooperative** – In cooperative patients with adequate spontaneous ventilation, preoxygenation can be performed with a nonrebreather mask with flush-flow rate oxygen. Traditional flow rates of 15 LPM provide inadequate preoxygenation since leak around the margin of the mask limits the FiO_2 to approximately 65 percent. Flush rate oxygen (40 to 70 LPM depending on the oxygen source and flow meter type) outcompetes room air entrainment around the margin of the mask and increases the FiO_2 to 90 percent or more, thereby providing maximal nitrogen washout and, thus, a larger oxygen reservoir [28]. However, flush rates of oxygen vary considerably among hospitals. Flow rates as low as 20 LPM have been reported [29,30]. Flush-flow rate oxygen is obtained by opening the knob on the flow meter completely (ie, until it won't turn any further in the "open" direction). If circumstances do not allow for three minutes of preoxygenation, eight full, vital-capacity breaths can provide adequate preoxygenation in cooperative patients within one minute.

- **Adequate spontaneous ventilation but uncooperative** – In patients who are uncooperative and unable to tolerate any preoxygenation efforts, a delayed sequence intubation (DSI) technique may be used. DSI involves the administration of a dissociative dose of ketamine (1.0 to 1.5 mg/kg IV), intended to sedate the patient sufficiently to allow effective preoxygenation without depressing respiratory drive. Once ketamine takes effect, preoxygenation is performed as for a cooperative patient with adequate spontaneous ventilation.

  Great care must be taken when using DSI, as even a small dose of ketamine in the critically ill can cause apnea or hypotension. The clinician should be ready to assume complete control of the airway (and manage hypotension) as soon as ketamine is administered.

  Studies of DSI are limited, and the safety of this technique has not been demonstrated, nor is it known whether this approach reduces adverse events compared with RSI in such patients. In particular, it is not known whether DSI is safer than providing oxygenation via positive pressure using a BVM beginning immediately after induction (see 'Adjunct strategies to maximize preoxygenation' below). In a small observational study in ICU and ED patients, those managed with DSI showed improvements in preoxygenation [31]. A before-and-after prehospital study reported that the implementation of a multi-interventional airway "bundle," including routine administration of ketamine to facilitate preoxygenation, reduced the rate of peri-intubation hypoxemia from 44 to 4 percent [32]. The bundle also required that oxygenation targets (>93 percent oxygen saturation for three minutes) be met before RSI could be performed. Therefore, the direct impact of ketamine is difficult to determine.

Right-to-left intrapulmonary shunting — When air-space disease (eg, pneumonia, ARDS) causes significant right-to-left intrapulmonary shunting, the above methods of preoxygenation may not be effective. Patients with such shunting require positive end expiratory pressure (PEEP) to promote alveolar recruitment and maximize the efficacy of preoxygenation efforts. Although a BVM with a PEEP valve may be used, we recommend noninvasive ventilation (NIV) in this setting [33,34]. The use of noninvasive ventilation for acute respiratory failure and the benefits of positive pressure ventilation to improve preoxygenation are reviewed separately. (See "Noninvasive ventilation in acute respiratory failure in adults".)

If a patient cannot tolerate NIV for preoxygenation, the use of a high flow nasal oxygen (HFNO) system (eg, Optiflow or Vapotherm) is a reasonable alternative [35-37]. Studies on HFNO for preoxygenation in the critically ill are mixed, but some have demonstrated favorable results [38,39]. (See "Heated and humidified high-flow nasal oxygen in adults: Practical considerations and potential applications" and "Preoxygenation and apneic oxygenation for airway management for anesthesia".)

Adjunct strategies to maximize preoxygenation — Additional strategies to prevent or delay oxygen desaturation during emergency airway management include the following [20]:

- **Proper positioning** – For patients not immobilized for possible spinal injury, preoxygenation is improved by placing them in at least a 20 degree head-up position [40-42]. Alternatively, 30 degree reverse Trendelenburg positioning (bed kept flat but tilted at an angle with patient's head up) may be used for immobilized patients. The benefits of the head-up or ramp position for obese patients are discussed separately. (See "Emergency airway management in the morbidly obese patient", section on 'Preoxygenation'.)

- **Continuous passive oxygenation during apnea** – During the apneic period of RSI, the airway manager can provide oxygen via nasal cannula at a flow rate of 15 LPM. As passive oxygenation (also known as apneic oxygenation) is a simple, low-cost intervention, we encourage its routine use during emergency intubation, particularly if intubation is anticipated to be difficult or prolonged, or the patient has reduced oxygen reserves. It should be used with care in patients that may be sensitive to the effects of hypercarbia, such as those with intracranial hypertension, metabolic acidosis, and pulmonary hypertension. (See "Preoxygenation and apneic oxygenation for airway management for anesthesia".)

  In several randomized trials involving stable surgical patients, passive oxygenation has been found to extend the safe apnea time [43-46]. However, the efficacy of passive oxygenation among the critically ill is more controversial [45-48]. Some observational studies have demonstrated a benefit in reducing the incidence of hypoxemia during emergency intubation [45,46], but two randomized trials, one in the ICU and one in the ED, found that passive

oxygenation did not reduce the prevalence of desaturation during intubation. Of note, in the ED study, nearly all patients were intubated in less than 120 seconds, likely eliminating any impact from passive oxygenation [47,48].

Meta-analyses of studies of passive oxygenation suggest benefit [49-52]. Passive oxygenation was associated with decreased prevalence of desaturation and increased first-pass intubation success. The latter finding is likely the result of more time for laryngoscopy and tracheal tube placement.

- **Gentle ventilation for patients who cannot tolerate apnea** – Many patients who are physiologically deranged (eg, hypotension, acidosis, refractory hypoxemia from intrapulmonary shunting) but require emergency intubation have a greatly reduced tolerance for apnea [15,17]. In such cases, the clinician may wish to perform a modified RSI technique that includes giving gentle, manual positive pressure ventilation during the "apneic" period of RSI [53]. Alternatively, RSI can be avoided altogether and an awake intubation performed [16]. Whenever possible, it is important to address underlying physiologic compromise prior to beginning RSI. (See 'Preintubation optimization' below.)

  A reasonable approach when deciding whether to provide mask ventilation during RSI is to assess the patient's relative risk for hypoxemia and aspiration. If the risk of desaturation and hypoxemia is high, gentle mask ventilation can be performed during induction; if the risk of aspiration is higher, mask ventilation should be avoided if at all possible.

  Bag-mask ventilation during the apneic period of RSI is most likely to benefit patients with overt severe hypoxemia or those who are anticipated to desaturate rapidly following the administration of RSI medications. These scenarios are more common among patients with severe respiratory disease who are often being treated in the ICU. Such ICU patients are often hypoxemic at baseline and at relatively low risk of aspiration because their stomachs are empty. Thus, the risk-benefit assessment often favors mask ventilation during RSI in these patients.

  Conversely, it is best not to perform bag mask ventilation during the apneic period of RSI in patients at relatively high risk of aspiration. Such patients are more common in the emergency department. They may include patients with active upper gastrointestinal bleeding, hematemesis, or vomiting, or victims of trauma with full stomachs or blood in their airway. The risk-benefit assessment favors not performing mask ventilation during RSI in these patients.

  The efficacy of gentle ventilation in this setting is supported by a multicenter trial performed in seven ICUs across the United States [54]. In this trial, 401 patients requiring intubation were randomly assigned to RSI with or without assisted ventilation using a bag-valve mask (BVM) during the induction phase. Patients in the ventilation group received BVM ventilation using 15

LPM of oxygen, peak end-expiratory pressure of 5 to 10 cm H_2O, a rate of 10 breaths per minute, a two-handed mask seal, an oropharyngeal airway, and the smallest volume necessary to generate visible chest rise. The ventilation group experienced a significantly lower prevalence of severe hypoxemia (SpO_2 <80 percent) compared with the no ventilation group (10.9 percent [21 patients] versus 22.8 percent [45 patients]; relative risk [RR] 0.48, 95% CI 0.30-0.77), while witnessed aspiration rates were similar (2.5 versus 4.0 percent). While these findings support the approach described, it should be noted that the study lacked standardized preoxygenation protocols or a flush rate oxygen control group, and patients identified as being at high risk for aspiration (eg, recent episodes of emesis, hematemesis, hemoptysis) were excluded from the trial.

- **Techniques to increase airway patency** – If necessary, patency of the upper airway can be maintained with adjuncts (nasal or oropharyngeal airways) and positioning maneuvers (chin lift and/or jaw thrust). The chin lift is not used when spinal precautions are being observed. (See "Basic airway management in adults", section on 'Airway maneuvers'.)

Preintubation optimization — Historically, the concept of the difficult airway was primarily related to anatomic factors that made laryngoscopy and delivery of the tracheal tube through the laryngeal inlet difficult. Subsequently, greater emphasis has been placed on physiologic abnormalities that complicate emergency airway management. "The physiologically difficult airway" is one in which physiologic derangements, such as hypotension and hypoxemia, place the patient at great risk of cardiovascular collapse during the peri-intubation period [15].

- Common conditions that cause or exacerbate **hypotension** following RSI and interventions to help prevent or manage them are summarized in the following table (table 5).

- Common conditions that cause or exacerbate **hypoxemia** following RSI and interventions to help prevent or manage them are summarized in the following table (table 4).

Preintubation optimization involves recognizing and addressing areas of physiologic vulnerability that may complicate resuscitative efforts, even if tracheal intubation goes quickly and smoothly. Several studies have evaluated the prevalence of peri-intubation arrest associated with critically ill patients in the ED and ICU and report rates ranging from 1.7 to 4.2 percent [55-58]. The two factors commonly found to be associated with intubation-associated cardiac arrest were hypoxemia and hypotension, suggesting that optimization of these two physiologic disturbances can help reduce intubation-associated morbidity and mortality. A prospective observational study performed in French ICUs reported that the introduction of a 10-point intubation care bundle resulted in the reduction of severe life-threatening complications from 34 to 21 percent [59]. Three of the components of this intubation

bundle were aimed at optimization of physiology: preoxygenation with NIV, IV fluid loading (in the absence of heart failure), and early vasopressor use.

Hemodynamic compromise should be aggressively managed with the goal of optimizing conditions prior to intubation. Simple examples include rapid infusion of packed red blood cells or decompression of a hemopneumothorax for a hypotensive blunt trauma patient before initiating intubation.

The most commonly encountered physiologic problem in patients requiring emergency intubation is hypotension. Bleeding, dehydration, sepsis, and acute cardiac disease are common emergency conditions that can result in peri-intubation complications and morbidity, despite successful tracheal tube placement. Nearly all induction agents can cause peripheral vasodilation and myocardial depression. Therefore, patients with reduced ejection fraction, depleted intravascular volume, or ongoing bleeding can suffer circulatory collapse after RSI drugs are administered. The risk is compounded by subsequent positive pressure ventilation, which decreases blood pressure further by increasing intrathoracic pressure and reducing venous return.

Depending on the cause of hypotension and the available time, isotonic crystalloid, blood products, and a vasopressor, such as norepinephrine or phenylephrine, can be used to address hypotension and increase the pharmacologic options for RSI. Oxygenation efforts are reassessed during this step and escalated as necessary.

While less common, hypertensive crises can be prevented or treated with sympatholytic agents (eg, fentanyl) prior to laryngeal manipulation and tube placement, both of which are known to cause sympathetic stimulation during intubation. (See "Treatment of severe hypovolemia or hypovolemic shock in adults" and "Mechanical ventilation of adults in the emergency department", section on 'Approach to ventilated patient in distress' and "Use of vasopressors and inotropes".)

Paralysis with induction — The concept of RSI is based on the virtually simultaneous IV administration of a rapidly acting induction agent and an NMBA (paralytic). Agent selection and dosing are aimed at producing unconsciousness and complete muscular relaxation quickly. RSI does **not** involve titration of either agent to reach this state. The dose of each agent is precalculated to achieve the desired effect. Onset of action after administration is variable depending on the agent chosen, but the goal is to achieve intubation-level sedation and paralysis 45 to 60 seconds after the drugs are given by IV push. A table summarizing RSI drug selection based upon the clinical scenario is provided (table 6).

Induction agents — The ideal induction agent for RSI acts quickly to provide a deep state of unconsciousness and analgesia without causing hemodynamic side effects. No available agent meets all criteria. Drugs currently available include etomidate, ketamine, midazolam and propofol. The

induction agents used for RSI are discussed in detail separately (see "Induction agents for rapid sequence intubation in adults outside the operating room"). A summary table of induction agents is provided (table 7).

Neuromuscular blocking agents — The use of an NMBA to produce rapid paralysis comprises the cornerstone of RSI. NMBAs do **not** provide analgesia or sedation. In the context of RSI, they are used immediately following an induction agent. Only two NMBAs have onset times short enough to be used for RSI: succinylcholine and rocuronium. These are discussed in detail separately. (See "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room".)

Positioning — This phase of RSI refers to positioning the patient for laryngoscopy and protecting against aspiration prior to placement of the tracheal tube by avoiding bag-mask ventilation. Bag-mask ventilation is unnecessary if the patient has been successfully preoxygenated and oxygen saturation remains above 92 percent. (See 'Preoxygenation' above.)

In addition, bagging between paralysis and intubation creates a potential hazard if gastric insufflation results in regurgitation and aspiration. Provided oxygen saturation remains above 92 percent, bag-mask ventilation is unnecessary, even between laryngoscopy attempts. If the patient's saturation percentage falls below 92, or is unknown, clinicians provide ventilatory support using a bag-mask.

Cricoid pressure (Sellick maneuver) — Although it was once widely recommended and used during RSI, we no longer recommend the routine use of cricoid pressure (Sellick maneuver) during laryngoscopy and intubation. The use of cricoid pressure during RSI for anesthesia is discussed separately (see "Rapid sequence induction and intubation (RSII) for anesthesia", section on 'Cricoid pressure during RSII').

Cricoid pressure has been shown to reduce gastric insufflation during bag-mask ventilation, but there is no convincing evidence that it reduces the incidence of aspiration of gastric contents during intubation [27,60-64]. Several studies suggest it may contribute to airway obstruction and difficulty intubating in some cases, even when a video laryngoscope is used [60,65-68]. However, it is reasonable to apply cricoid pressure during RSI if bag-mask ventilation is necessary, and encouraged if high pressures are needed to provide adequate ventilation using a bag mask.

A systematic review of cricoid pressure studies noted the following [60]:

- Case series and retrospective reviews describe both the success and failure of cricoid pressure to prevent aspiration.
- Cricoid pressure is often used inconsistently and applied improperly in all airway management settings.

- Cricoid pressure may impair the function of the lower esophageal sphincter.
- Possible risks from cricoid pressure include movement of unstable cervical spine fractures and esophageal injury.

Placement with proof — After neuromuscular relaxation is achieved, as assessed by masseter muscle tone (ie, laxity of the jaw with no resistance to mouth opening), laryngoscopy can be performed. The time to muscular relaxation will vary depending on the NMBA used and dosing. When used with an appropriate induction agent, succinylcholine generally produces excellent intubating conditions within 45 seconds, compared with rocuronium, which does so in 60 seconds. If the patient is not felt to have achieved full neuromuscular paralysis at 45 or 60 seconds, we recommend waiting an additional 15 to 30 seconds for this to occur.

The goal of laryngoscopy is clear visualization of the glottic aperture. Once the glottis is visualized, the clinician places the endotracheal tube (ETT) between the vocal cords, inflates the cuff, withdraws the stylet, and confirms placement. The performance of laryngoscopy is described in detail separately. (See "Direct laryngoscopy and endotracheal intubation in adults" and "Devices for difficult emergency airway management in adults outside the operating room" and "Video laryngoscopes and optical stylets for airway management for anesthesia in adults", section on 'Videolaryngoscopy'.)

Confirmation of proper ETT placement is crucial; unrecognized esophageal intubation leads to devastating complications. Waveform capnography is the most accurate means of confirming ETT placement, and we recommend it be used with every intubation. If not available, then capnometry or colorimetric $ETCO_2$ devices can be used. Clinical indicators alone, such as visualization of the ETT through the cords, misting of the tube with ventilation, and auscultation of breath sounds over the lung fields, **cannot** be relied upon to confirm proper ETT placement. A single-view chest radiograph is only useful to determine depth of placement (eg, supraglottic versus tracheal versus mainstem). It is not useful for distinguishing tracheal from esophageal intubation.

The methods for proving proper ETT placement are discussed in greater detail separately. (See "Direct laryngoscopy and endotracheal intubation in adults", section on 'Confirming proper tracheal tube placement'.)

Postintubation management — RSI remains incomplete until the properly placed ETT is secured. Several techniques are commonly used to secure the tube, including taping, tying, and using proprietary tube-holders. The technique employed for ED airway management should be readily available, easy to apply, and secure. A post-procedural chest radiograph is obtained to confirm depth of tube placement and to evaluate for evidence of barotrauma as a consequence of positive pressure ventilation. Mechanical ventilation is initiated. Ventilator settings may need modification according to clinical circumstance. (See "Direct laryngoscopy and endotracheal intubation in adults", section on

'Post-intubation management' and "Mechanical ventilation of adults in the emergency department", section on 'Disease-specific ventilatory management'.)

Minor reductions in oxygen saturation and blood pressure may be observed in the immediate post-intubation period as a result of apnea and administration of the induction agent. If these do not rebound quickly with fluids and positive pressure ventilation, or if previously stable vital signs suddenly deteriorate after tube placement, the clinician should quickly search for signs of a peri-intubation adverse event. These may include pneumothorax, tracheal tube cuff rupture, mucus plugging, interruption of the oxygen circuit, or esophageal intubation.

If long-term paralysis is needed, the timing of subsequent doses of both paralytic and sedative agents should be anticipated. Providing both long-term analgesia and sedation is important given the relatively short duration of action of the agents frequently used for RSI and the ability of paralysis to obscure the patient's capacity to communicate pain or distress. Increases in heart rate or blood pressure may be an indication of inadequate sedation while paralyzed. Appropriate analgesia and sedation, guided by a sedation scale, often obviates the need for neuromuscular paralysis to permit mechanical ventilation. (See "Sedative-analgesic medications in critically ill adults: Selection, initiation, maintenance, and withdrawal".)

Although RSI provides optimal conditions for laryngoscopy, it is not without drawbacks. Many critically patients suffer from hypoxemia or hypotension during the peri-intubation period. To minimize the risk of these complications, patients should be physiologically optimized prior to intubation [15,59]. Properly performed preoxygenation using the most appropriate methods given the clinical circumstances is the most important measure that can be undertaken to prevent desaturation. Passive oxygenation can be used to prolong the safe apnea time. The administration of IV fluids, blood products, and vasopressors, as clinically indicated, to optimize hemodynamics is recommended prior to intubation. (See 'Preintubation optimization' above.)

SUMMARY AND RECOMMENDATIONS

- Rapid sequence intubation (RSI) uses a rapidly acting induction agent and a neuromuscular blocking agent (NMBA) to create optimal intubating conditions and enable rapid control of the airway. RSI presupposes the patient is at risk for aspiration of gastric contents and incorporates medications and techniques to minimize this risk. The basic approach to RSI consists of the "Seven P's" as outlined below and in the text.

- Preparation – Assess the patient for anatomic features or clinical findings that indicate the patient may be difficult to intubate or to ventilate using a bag-mask. Make an airway management plan,

including a backup approach, based on the clinical scenario. Gather equipment and medications. Necessary equipment is described in the text. (See 'Preparation' above.)

- Preoxygenation – Preoxygenation with flush-flow oxygen for at least three minutes and passive oxygenation via high-flow nasal cannula thereafter is recommended for all patients being intubated with RSI. Strategies to maximize preoxygenation are provided in the text. (See 'Preoxygenation' above.)

  Preoxygenation creates an oxygen reservoir in the lungs, blood, and tissues that enables patients to tolerate a longer period of apnea without desaturation. The oxygen saturation of adults with severe illness or obesity, and pregnant women nearing the end of their third trimester, falls below 90 percent in less than 3 minutes, even if ideal preoxygenation is achieved. Time to desaturation in emergency practice is often more rapid than anticipated.

- Preintubation optimization – Unless the need for intubation is immediate, patients undergoing emergency intubation should be physiologically optimized prior to the procedure. This includes hemodynamic optimization with IV fluids, blood products, and vasopressors as necessary, relief of hemopneumothorax and hemostasis for trauma patients, and maximal preoxygenation for all. (See 'Preintubation optimization' above.)

  - **Hypotension** following RSI and interventions to help prevent or manage it are summarized in the following table (table 5).

  - **Hypoxemia** following RSI and interventions to help prevent or manage it are summarized in the following table (table 4).

- Paralysis with induction – RSI involves the virtually simultaneous IV administration of a rapidly acting induction agent and a NMBA to quickly produce deep sedation and muscular relaxation. The characteristics of the induction agents used for RSI are summarized in the following table (table 7). A table summarizing RSI drug selection based upon the clinical scenario is also provided (table 6). (See "Induction agents for rapid sequence intubation in adults outside the operating room" and "Neuromuscular blocking agents (NMBAs) for rapid sequence intubation in adults outside of the operating room".)

- Positioning – This step refers to protecting the airway prior to placement of the tracheal tube by avoiding bag-mask ventilation. Bag-mask ventilation is unnecessary if the patient has been successfully preoxygenated and is at low risk for oxygen desaturation. Ventilation interposed between paralysis and intubation creates a potential risk for regurgitation and aspiration. (See 'Positioning' above.)

- Placement with proof – Once intubation is performed, confirmation of proper tracheal tube placement is crucial. End-tidal CO2 determination (either colorimetric or quantitative) must be performed to determine proper placement. (See "Direct laryngoscopy and endotracheal intubation in adults", section on 'Confirming proper tracheal tube placement'.)

- Postintubation management – The tracheal tube must be secured, a postintubation chest radiograph checked for positioning and evidence of complications, and appropriate ventilator management begun. Drugs used for RSI are generally short-acting and the clinician must provide adequate longer-term sedation, analgesia, and sometimes paralysis. (See 'Postintubation management' above and "Mechanical ventilation of adults in the emergency department".)

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Topic 270 Version 44.0

GRAPHICS

Intubation of COVID-19 patients outside the OR: Guidelines and modifications[1-4]

Key principles	
▪ Maximize first-attempt success while keeping patients and providers safe. ▪ Prevent contamination and spread of virus. There is a high risk of aerosolization of virus during airway management.	
RSI steps (seven P's)	**Important actions and modifications**
Preparation	▪ Use checklist adapted for COVID-19 patients. Placing required airway equipment and medications in prepackaged bundles may be helpful.
	▪ Review airway plan as a team before entering room. RSI preferred whenever possible. Avoid awake intubation (cough during awake intubation increases viral spread).
	▪ Prepare all required equipment and draw up and label all medications (including induction agent, NMBA, vasopressor [eg, norepinephrine infusion], isotonic IVF) before entering intubation room.
	▪ Keep **all** nonessential equipment just outside room.
	▪ Have available all standard airway equipment plus: • Bag-mask **with HEPA filter** • Video laryngoscope with clear, disposable cover for the device • Ventilator and tubing **with in-line adaptors** (for suctioning and bronchoscopy) and **HEPA filters** • Waveform capnography if available • Smooth clamp for ETT
	▪ Use negative pressure room for intubation whenever possible.
	▪ Limit intubation team in room to 3 members: intubator, nurse, respiratory therapist.
	▪ If possible, second intubator wearing PPE should remain outside room to assist with anticipated difficult airway or as necessary.
	▪ Before entering room: • Perform hand hygiene. • Don PPE with proper technique and supervision. • Use N95 mask with face shield or PAPR. • Don double gloves, eye protection (airtight goggles if available), gown, and head cap. • Prepare marked bags for proper disposal/removal of clothing and equipment.
	▪ The precautions against infection listed immediately above should be taken by all clinicians directly involved in any pediatric intubation or airway management. Children are much more likely to be asymptomatic carriers and pose a risk for disease transmission.
	▪ Avoid pretreatment with nebulizers if possible; use MDI instead.
Preoxygenation	▪ Preoxygenate patient for 3 to 5 minutes with 100% O_2 using low or moderate flow rates (10 to 15 L/minute) and NRB mask. Avoid BMV if at all possible. 5 minutes of preoxygenation preferred if circumstances permit.
	▪ If needed, can preoxygenate with modified NIV by using tightly fitting, non-vented mask connected to closed-circuit, dual-limb ventilator with HEPA filter. Use a full-face mask if available (reduces aerosolization). Mask must fit standard ventilator tubing. Continue NIV until patient apneic. Suspend ventilator before removing mask for intubation.

	▪ If patient remains hypoxic (SpO_2 <93%) using NRB mask and NIV with closed circuit not available, can use BMV with HEPA filter and PEEP valve. Hold mask tightly on patient's face using 2-hand thenar technique, increase oxygen flow rate as needed, and have patient breathe passively. Perform synchronized bag-assist ventilation only if required.
	▪ Avoid high-flow oxygenation methods (eg, flush rate) unless clinically required.
	▪ Avoid nasal cannula for oxygenation, including apneic oxygenation.
	▪ Upright posture or reverse Trendelenberg positioning improves preoxygenation.
	▪ Avoid BMV if at all possible; use HEPA filter if BMV must be performed.
	▪ If BMV necessary, 2-person thenar technique gives better seal and reduces aerosolization/contamination risk (provided entry of additional provider can be avoided). Provide BMV using low volumes and relatively high rates.
Pre-intubation optimization	▪ May give IV fluid bolus prior to giving RSI medications to patients who are volume depleted.
	▪ Avoid high-volume fluid resuscitation in COVID-19 patients at risk for ARDS.
	▪ Push-dose pressor may be needed for patients at high risk for hemodynamic decompensation (options include phenylephrine 100 micrograms IV or epinephrine 10 micrograms IV).*
	▪ Vasopressor (eg, norepinephrine) infusion may be needed for patients with hypotension or hemodynamic instability before or following administration of RSI medications.
Paralysis with induction	▪ Use high-dose NMBA: rocuronium 1.5 mg/kg IV or succinylcholine 2 mg/kg IV. Goal is rapid-onset apnea and elimination of cough.
Protection of patient and staff	▪ Refer to "Preparation" above and "Post-intubation management" below.
Placement (intubation)	▪ Use video laryngoscopy whenever possible.
	▪ Performed by experienced intubator.
	▪ Supraglottic airway preferred for rescue oxygenation and ventilation if needed (eg, intubation difficulty).
	▪ Ensure ETT is inserted 19 to 22 cm (measured at teeth); may reduce need for confirmation by chest radiograph.
Post-intubation management	▪ Inflate cuff immediately following ETT placement and **prior** to initiating PPV.
	▪ Confirm placement of the ETT. If a colorimeter or other removable $EtCO_2$ detector is used, clamp the ETT before removing the device.
	▪ After confirming ETT placement, clamp the ETT, connect the ventilator tubing, and then remove the clamp. HEPA filter between ETT and ventilator should be in place. Start mechanical ventilation. Secure the ETT.
	▪ Ventilator settings suitable for patient with ARDS are likely to be needed (assuming COVID-19-related respiratory illness is reason for intubation). ¶
	▪ Procedure bundles can reduce exposure. May choose to perform intubation and central venous catheter placement together and then obtain portable chest radiograph to assess both.
	▪ Limit ventilator disconnections. When disconnection required, clamp ETT first and disconnect at end-expiration.
	▪ Ideally, use ETT and ventilator with in-line adaptors for suctioning and bronchoscopy.

	▪ Ensure adequate sedation for patient care and safety and to avoid accidental extubation or disconnection of tubing.
	▪ Bag, transport, and clean all equipment as required.
	▪ Use proper PPE doffing, supervised by coach or other team member, including hand hygiene.

RSI: rapid sequence intubation; NMBA: neuromuscular blocking agent (paralytic medication); IVF: intravenous fluid; OR: operating room; ETT: endotracheal tube; PPE: personal protective equipment; PAPR: powered air-purifying respirator; MDI: metered dose inhaler; O_2: oxygen; BVM: bag-valve mask; NRB: nonrebreather; NIV: noninvasive ventilation; HEPA: high-efficiency particulate air; ARDS: acute respiratory distress syndrome; IV: intravenous; PPV: positive-pressure ventilation; $EtCO_2$: end-tidal carbon dioxide; SBP: systolic blood pressure; FiO_2: fraction of inspired oxygen.
* The use of a push-dose pressor is based on clinical judgement. It is most appropriate for patients with overt shock (eg, SBP <90 mmHg, SI >1) but may be useful in any hemodynamically unstable patient being intubated. For adults, options include phenylephrine 100 micrograms (50 to 200 micrograms) IV or epinephrine 10 micrograms (5 to 20 micrograms) IV, depending upon whether vasoconstriction alone or vasoconstriction and inotropic support is desired. Appropriate measures to improve hemodynamics as much as possible should be taken prior to intubation and push-dose pressor use.
¶ Initial ventilator management for adults with ARDS includes low tidal volume (6 mL/kg predicted body weight), volume-limited assist control mode, positive end-expiratory pressure (10 to 15 cm H_2O), and high FiO_2 (1.0). These settings are modified based on patient response. Refer to UpToDate topics discussing ventilator management in ARDS for details. For initial settings in children, please refer to UpToDate topics on initiating mechanical ventilation in children.

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Graphic 127516 Version 12.0

Summary: The Seven Ps of rapid sequence intubation

Action	Time
Preparation	10 minutes before intubation
Preoxygenation	5 minutes before intubation
Pre-intubation optimization	3 minutes before intubation (may be longer depending on necessary interventions and time available)
Paralysis with induction	Induction
Protection	30 seconds after induction
Placement (Intubation)	45 seconds after induction
Post-intubation management	60 seconds after induction

Used with permission from Brown III CA, Sakles JC, Mick N. The Walls Manual of Emergency Airway Management, 5th edition. 2018. Wolters Kluwer.

Graphic 77060 Version 4.0

Mnemonic for tracheal intubation preparation

S: Suction
T: Tools for intubation (laryngoscope blades, handle, video laryngoscope and other preferred devices)
O: Oxygen source for preoxygenation and ongoing ventilation
P: Positioning
M: Monitors, including ECG, pulse oximetry, blood pressure, $EtCO_2$, and esophageal detectors
A: Assistant; Ambu bag with face mask; Airway devices (ETTs, syringe, stylets, LMA); Airway assessment
I: Intravenous access
D: Drugs, including induction agent, neuromuscular blocking agent, and desired adjuncts (eg, IV fluids, vasopressor, fentanyl)

ECG: electrocardiogram; $EtCO_2$; end-tidal carbon dioxide; ETTs: endotracheal tubes; IV: intravenous; LMA: laryngeal mask airway.

Graphic 79150 Version 4.0

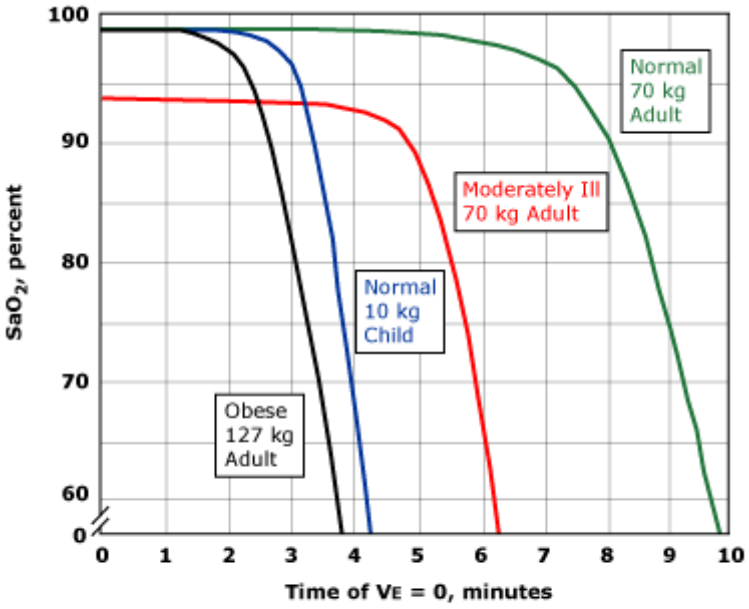
Post-RSI hypoxemia: Common causes and interventions

Common causes	Important clinical findings	Interventions	Prevention and preparation
ETT malposition (dislodged; esophageal placement)	▪ Bilateral decreased breath sounds ▪ Gastric breath sounds (esophageal intubation) ▪ Low PIP	▪ Extubate and reintubate	▪ Waveform capnography
Mainstem intubation	▪ Asymmetric breath sounds ▪ High resistance to BMV ▪ High PIP	▪ Withdraw ETT appropriate distance and recheck breath sounds	▪ Insert ETT appropriate distance ▪ Keep ETT well secured
ETT cuff malfunction	▪ Ventilator leak or low ventilation volumes ▪ Loss of pilot balloon pressure	▪ Exchange ETT	▪ Inflate and check cuff of primary and backup ETT prior to intubation
Mucus plugging	▪ Increased secretions ▪ High resistance to BMV ▪ High PIP	▪ ETT suctioning	▪ Suction frequently if heavy secretions
Rapid desaturation (causes: obesity, late term pregnancy, inadequate preoxygenation, intrapulmonary shunt [eg, ARDS, pneumonia])	▪ Sudden drop in oxygen saturation very soon after induction and neuromuscular blockade	▪ Rescue mask ventilation with oral and nasal airways ▪ Rescue extraglottic device	▪ Maximize preoxygenation: • Upright sitting (if no concern for c-spine injury) or reverse Trendelenburg position • Flush-rate oxygen • BiPAP and PEEP • Continuous passive oxygenation
Profound shock or anemia	▪ Specific findings vary with cause; refer to UpToDate topics and graphics on rapid sequence intubation		
Pneumothorax	▪ Asymmetric breath sounds ▪ Subcutaneous emphysema ▪ High resistance to BMV ▪ High PIP	▪ Needle thoracostomy (temporizing) ▪ Tube thoracostomy	▪ 18 gauge needle or chest tube kit at the bedside for high-risk patients
Oxygen apparatus malfunction	▪ Hypoxemia unexplained by clinical findings	▪ Confirm oxygen source functioning, connections secure, and tubing intact	

RSI: rapid sequence intubation; ETT: endotracheal tube; PIP: positive inspiratory pressure; BMV: bag-mask ventilation; ARDS: acute respiratory distress syndrome; c-spine: cervical spine; BiPAP: bilevel positive airway pressure; PEEP: positive end-expiratory pressure.

Graphic 121731 Version 2.0

Time to oxygen desaturation



Mean time to recovery of twitch height from 1 mg/kg succinylcholine IV

SaO_2, percent	10	50	90
Time of VE = 0, minutes	6.8	8.5	10.2

Preoxygenation prolongs the period between paralysis with succinylcholine and oxygen desaturation in all patients, but to varying degrees depending on patient attributes. This diagram shows the time to desaturation for several different clinical conditions.

Graphic 56716 Version 12.0

Post-RSI hypotension: Common causes and interventions

Common causes	Important clinical findings	Interventions	Prevention/preparation
High intrathoracic pressure ▪ Poor BMV ventilation technique ▪ Improper mechanical ventilation settings	▪ Normal or elevated airway pressures ▪ Abnormal breath sounds (eg, wheezing, diminished)	▪ Slow ventilation rate (≤8 bpm) ▪ Reduce ventilation force (for BMV) ▪ Increase expiration time ▪ IV bolus isotonic fluid	▪ Avoid overly rapid or forceful ventilation
Induction agent effects	▪ Occurs within minutes of drug administration ▪ Transient effect ▪ Resolves with IVF bolus and time	▪ IV bolus isotonic fluid ▪ Norepinephrine infusion ▪ Exclude other serious causes ▪ Monitor for resolution	▪ Prepare norepinephrine infusion prior to giving induction agent to patient with hypotension or signs of hemodynamic instability ▪ Consider push-dose pressor*
Significant prior or ongoing fluid loss	▪ Signs of shock ▪ SI >0.8 ▪ POCUS shows decreased IVC diameter and hyperdynamic heart	▪ IV bolus isotonic fluid; repeat as needed	▪ In hypotensive or high-risk patients, give IVF bolus prior to administering RSI medications
Significant prior or ongoing hemorrhage	▪ Blood loss ▪ Signs of shock ▪ Pallor	▪ Blood transfusion ▪ Hemorrhage control/surgical consultation	▪ In patients with hemorrhagic shock or at risk for hemodynamic instability, initiate blood transfusion prior to administering RSI medications
Obstructive shock			
▪ Pulmonary embolism	▪ Possible hypoxemia ▪ Lower extremity swelling ▪ Dilated RV on POCUS or bedside echo	▪ Norepinehrine infusion ▪ iNO or epoprostenol (reduce PVR)	▪ Give norepinephrine early as needed ▪ Consider push-dose pressor* ▪ For shock caused by PE, avoid intubation if possible; use BPAP or iNO to improve oxygenation/ventilation ▪ Ketamine is preferred induction agent for patients in non-cardiogenic shock; avoid propofol ▪ Reduce dose of induction agent¶ ▪ In hypotensive or high-risk patients with tamponade, give IVF bolus prior to administering RSI medications
▪ Cardiac tamponade	▪ Distended neck veins, if patient not volume depleted ▪ POCUS shows pericardial effusion and compression of RA and RV	▪ IV bolus isotonic fluid ▪ Pericardiocentesis	
Cardiogenic shock	▪ Crackles, distended neck veins, cool extremities ▪ ECG may show ischemia	▪ Minimize PEEP ▪ Vasopressor (norepinephrine) and inotrope (dobutamine) infusions	▪ BPAP as indicated before RSI ▪ Etomidate is preferred induction agent for patients in cardiogenic shock; avoid propofol

	▪ POCUS shows poor contractility, B lines ▪ Chest radiograph may show signs of ADHF	▪ Interventional cardiology consult (catheterization; IABP; LVAD)	▪ Prepare norepinephrine infusion prior to giving induction agent ▪ Consider push-dose pressor*
Distributive shock			
▪ Sepsis	▪ Fever, hypotension, tachycardia, focal signs of infection	▪ IV bolus isotonic fluid; repeat as needed ▪ Norepinephrine infusion for sepsis	▪ In hypotensive or high-risk patients, give IVF bolus prior to administering RSI medications ▪ Ketamine is preferred induction agent for patients in non-cardiogenic shock; avoid propofol ▪ Give norepinephrine for sepsis early as needed ▪ Reduce dose of induction agent¶ ▪ Consider push-dose pressor*
▪ Anaphylaxis	▪ Skin and mucosal signs (hives, flushing, edema) ▪ Respiratory signs (wheeze, cough, congestion)	▪ IV bolus isotonic fluid; repeat as needed ▪ Epinephrine for anaphylaxis	
Older adult patient with poor CV reserve	▪ Frail appearing ▪ ECG may show ischemia ▪ History of CAD or reduced EF	▪ IV bolus isotonic fluid ▪ Norepinehrine infusion	▪ Prepare norepinephrine infusion prior to giving induction agent ▪ Reduce dose of induction agent¶ ▪ Consider push-dose pressor*

RSI: rapid sequence intubation; BMV: bag-mask ventilation; bpm: beats per minute; IV: intravenous; IVF: intravenous fluid; SI: shock index; POCUS: point-of-care ultrasound; IVC: inferior vena cava; RV: right ventricle; iNO: inhaled nitric oxide; PVR: pulmonary vascular resistance; PE: pulmonary embolism; BPAP: bilevel positive airway pressure; RA: right atrium; ECG: electrocardiogram; ADHF: acute decompensated heart failure; PEEP: peak end-expiratory pressure; IABP: intra-aortic balloon pump; LVAD: left-ventricular assist device; CV: cardiovascular; CAD: coronary artery disease; EF: ejection fraction; SBP: systolic blood pressure.

* The use of a push-dose pressor is based on clinical judgement. It is most appropriate for patients with overt shock (eg, SBP <90 mmHg, SI >1) but may be useful in any hemodynamically unstable patient being intubated. Options include phenylephrine 100 microgram (50 to 200 microgram) IV or epinephrine 10 microgram (5 to 20 microgram) IV, depending upon whether vasoconstriction alone or vasoconstriction and inotropic support is desired. Appropriate measures to improve hemodynamics as much as possible should be taken prior to intubation and push-dose pressor use.

¶ Reductions in the dose of the induction agent depend upon clinical circumstance. In general, the authors reduce the ketamine dose by 50% when a reduction is needed. Reductions in the etomidate dose are generally not necessary.

Graphic 120804 Version 2.0

Medication selection for RSI in adults by clinical setting

Clinical scenario	Induction agent*	Neuromuscular blocking agent*¶	Physiologic optimization (including pre-induction medications)Δ
Elevated ICP (head injury, stroke)	Etomidate 0.3 mg/kg IV or ketamine 1 to 2 mg/kg IV (avoid ketamine if signs of cerebral herniation; ketamine preferred in patients with severe hypotension)	Succinylcholine¶ 1.5 mg/kg IV or rocuronium 1 to 1.2 mg/kg IV	May give fentanyl 3 mcg/kg IV over 30 to 60 seconds, if time permits and patient is not in shock, for conditions exacerbated by rise in ICP (eg, acute brain injury, ischemic stroke, intracranial hemorrhage, meningitis, encephalitis, cerebral edema)
Cardiovascular emergency excluding cardiogenic shock (ACS, aortic dissection)	Etomidate	Succinylcholine or rocuronium	May give fentanyl 3 mcg/kg IV over 30 to 60 seconds, if time permits
Shock	Ketamine or etomidate (reduce dose by half for cardiogenic shock; ketamine preferred by some for septic shock)	Succinylcholine 2 mg/kg IV or rocuronium	Pre-RSI management depends on cause and may include: ▪ Hypovolemic shock: Isotonic IVF bolus ▪ Hemorrhagic shock: Blood transfusion ▪ Septic shock: Isotonic IVF bolus; vasopressor (norepinephrine)
Reactive airway disease			
Stable blood pressure	Ketamine or propofol 1.5 to 2 mg/kg IV	Succinylcholine or rocuronium	Pre-RSI management may include NPPV, heliox, high-flow oxygen (in addition to albuterol and other standard medical therapy)
Hypotensive/unstable	Ketamine or etomidate	Succinylcholine or rocuronium	
Prolonged seizure activity	Propofol or etomidate	Succinylcholine preferred (rocuronium may be used if EEG monitoring immediately available)	
Geriatric patient	Etomidate preferred (reduce dose by half if frail, hypotensive, or significant comorbidity)	Succinylcholine or rocuronium	Physiologic optimization may include isotonic IVF bolus, blood transfusion, and/or vasopressor (norepinephrine) infusion for hypotensive patients or those at risk of hypotension with RSI

RSI: rapid sequence intubation; ICP: intracranial pressure; IV: intravenous; ACS: acute coronary syndrome; IVF: intravenous fluids; EEG: electroencephalogram; NPPV: noninvasive positive pressure ventilation; ECG: electrocardiogram.

* Standard dose is provided once in the table but is the same for all conditions unless otherwise specified.

¶ Succinylcholine is contraindicated with:
- Malignant hyperthermia (patient or family history)
- Neuromuscular disease with denervation
- Muscular dystrophy
- Stroke over 72 hours old
- Rhabdomyolysis
- Significant burn over 72 hours old

- Hyperkalemia with ECG changes

Δ For more details about physiologic optimization, please refer to the UpToDate topics on RSI.

Graphic 122488 Version 2.0

Rapid sequence intubation induction agents for adults

Drug name	Class	Benefits	Contraindications	Notes	Dose
Etomidate	Imidazole derivative	Excellent sedation with little hypotension	Known to suppress adrenal cortisol production	Use cautiously if patient has sepsis; initial dose of glucocorticoid may be needed	0.3 mg/kg
Ketamine	Phencyclidine derivative, dissociative anesthetic	Stimulates catecholamine release Bronchodilation	Use in patients with elevated ICP or elevated blood pressure is controversial	May be an excellent induction agent for patients with bronchospasm, septic shock, **AND** hemodynamic compromise	1 to 2 mg/kg
Midazolam	Benzodiazepines	Potent dose-related amnesic properties	Dose-related myocardial depression can result in hypotension	Frequently underdosed	0.2 to 0.3 mg/kg
Propofol	Alkylphenol derivative	Bronchodilation	No absolute contraindications Dose-related hypotension		1.5 to 3 mg/kg
Thiopental sodium	Ultrashort-acting barbiturate	Cerebroprotective and anti-convulsive properties	Potent venodilator and myocardial depressant; can cause hypotension Relatively contraindicated in reactive airway disease due to histamine release Acute intermittent and variegate porphyrias	May not be commercially available. Rarely used.	3 to 5 mg/kg

Graphic 64272 Version 10.0

Contributor Disclosures

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