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SPECIAL FEATURE

Timing of Initiation of Renal Replacement Therapy in the ICU

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Dr. Nadler reports no financial relationships relevant to this field of study.

Acute kidney injury (AKI) is common in patients admitted to the ICU and is associated with high mortality. The decision to initiate renal replacement therapy (RRT) for these patients is complicated. Not only is the optimal time for starting therapy unclear, decisions to transfer patients to higher levels of care often are driven by the perceived need to initiate hemodialysis or continuous RRT.

CRITERIA FOR ACUTE KIDNEY INJURY

Multiple systems to grade AKI have been developed. These include the RIFLE criteria (Risk, Injury, Failure, Loss, End-stage kidney disease), KDIGO criteria (Kidney Disease: Improving Global Outcomes), and AKIN criteria (Acute Kidney Injury Network).[1-3] *(See Table 1.)* Investigators have studied the ability of each of these criteria to predict mortality. The authors of a multicenter, prospective analysis of 3,107 patients admitted to the ICU demonstrated rates of AKI varying from 38.4% with AKIN to 46.9% with RIFLE to 51% with KDIGO.[4] The areas under the curve for each receiver operator characteristic (ROC) for in-hospital mortality were 0.746 for AKIN, 0.738 for RIFLE, and 0.757 for KDIGO. Similarly, the authors of a retrospective, observational study of 49,518 patients admitted to the hospital reported ROC for hospital mortality of 0.69, 0.77, and 0.78 for AKIN, RIFLE, and KDIGO, respectively.[5] Specifically in patients admitted to the ICU with sepsis, the ROCs for in-hospital mortality with each criterion were similar for each system (RIFLE, 0.652; AKIN, 0.686; KDIGO, 0.658).[6]

These models of AKI predict mortality, not the need for RRT. This prompted the development of biomarkers that may be more predictive of the need for RRT. Beyond serum creatinine (sCr), these markers include serum cystatin C (sCysC) and urinary neutrophil gelatinase-associated lipocalin (uNGAL), as well as others. The utility of these remains an area of continuing study. The authors of a prospective study of

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310 patients receiving mechanical ventilation (MV) demonstrated ROCs for RRT for uNGAL of 0.727 and sCysC of 0.764, compared with sCr of 0.785 and Acute Physiology and Chronic Health Evaluation (APACHE) II severity of 0.728.[7] Combining these markers improved their predictive accuracy but they did not perform much better than the sCr and APACHE II scores alone. Thus, predicting which patients will require RRT remains difficult.

CLINICAL TRIALS EXAMINING TIMING OF RRT

With the uncertainty in predicting which patients will need RRT, the last few years have seen the authors of several randomized, controlled trials evaluate the best initiation approach. These include the ELAIN and AKIKI trials in 2016 and the IDEAL-ICU study in 2018.[8-10] Other studies dating back to 2002 were included in a systematic review and meta-analysis in 2017 that did not include the IDEAL-ICU trial.[11]

The ELAIN trial was a single-center, parallel group trial of 231 patients admitted to the ICU.[8] It included patients aged 18-90 years with KDIGO stage 2 and a marker of disease severity (sepsis, vasopressor requirement, refractory fluid overload, Sequential Organ Failure Assessment score ≥ 2). The criteria also included plasma NGAL > 150 ng/mL as a predictor of the need for RRT. It is notable that most patients were admitted with surgical indications. Exclusion criteria included chronic kidney disease (glomerular filtration rate [GFR] less than 30 mL/min), previous RRT, occlusion of the renal artery, glomerulonephritis, interstitial nephritis, vasculitis, post-renal obstruction, or thrombotic thrombocytopenic purpura/hemolytic uremic syndrome. Patients were randomized to early or delayed start of RRT. Early initiation occurred within eight hours of KDIGO stage 2, while delayed initiation occurred within 12 hours of KDIGO stage 3 AKI. Patients in the delayed initiation group could start early if any of the absolute indications for RRT were met (blood urea nitrogen [BUN] > 100 mg/dL, potassium > 6 mmol/L, or ECG changes, magnesium > 8 mEq/L, or urine production < 200 mL per 12 hours). Protocolized delivery of RRT ensured all patients received similar continuous venovenous hemodiafiltration. In this study, early initiation was associated with reduced 90-day mortality (hazard ratio [HR], 0.66; $P = 0.03$), the primary outcome. However, 28- and 60-day mortality rates in the early and delayed groups were not statistically different. Patients in the early

Table 1. Comparison of Criteria for Acute Kidney Injury

Category	Serum Creatinine	Urine Output
RIFLE		
Risk	1.5 times baseline or glomerular filtration rate (GFR) decrease > 25%	< 0.5 mL/kg/hour for 6 hours
Injury	2 times baseline or GFR decrease > 50%	< 0.5 mL/kg/hour for 12 hours
Failure	> 3 times baseline, or GFR decrease > 75%, or increase > 4 mg/dL	< 0.3 mL/kg/hour for 24 hours or anuria for 12 hours
KDIGO		
Stage 1	1.5-1.9 times baseline or ≥ 0.3 mg/dL increase	< 0.5 mL/kg/hour for 6-12 hours
Stage 2	2.0-2.9 times baseline	< 0.5 mL/kg/hour for ≥ 12 hours
Stage 3	3.0 times baseline or increase to ≥ 4.0 mg/dL	< 0.3 mL/kg/hour for ≥ 24 hours or anuria for ≥ 12 hours
AKIN		
Stage 1	1.5-2 times baseline or increase ≥ 0.3mg/dL	< 0.5 mL/kg/hour for > 6 hours
Stage 2	2-3 times baseline	< 0.5 mL/kg/hour for > 12 hours
Stage 3	> 3 times baseline or > 4 mg/dL and increase of > 0.5 mg/dL	< 0.3 mg/kg/hour for 24 hours or anuria for 12 hours

initiation arm had shorter hospital length of stay (LOS) and shorter duration of MV.

The AKIKI trial was a multicenter, randomized trial of patients with KDIGO stage 3 disease who required MV, vasopressors, or both. Patients were excluded if they had severe metabolic abnormalities, including BUN greater than 112 mg/dL, potassium > 6 mmol/L, pH < 7.15, or acute pulmonary edema requiring > 5 L/min O_2. In the early initiation group, researchers started RRT within six hours of KDIGO stage 3. Meanwhile, in the delayed group, RRT was started if patients progressed to the above-mentioned exclusion criteria or if they became anuric for more than 72 hours after randomization. The choice of RRT was left to each study site; thus, there was some variability in the mode of RRT. The primary outcome was 60-day mortality. Most patients presented with severe sepsis or septic shock (> 70%). Unlike the ELAIN trial, the AKIKI trial investigators demonstrated no significant difference in 60-day mortality between the early and delayed groups. Although there were more patients in the early initiation arm who received RRT, the only other secondary outcomes that showed a difference was a higher incidence of catheter-related bloodstream infections in the early initiation arm (10% vs. 5%; *P* = 0.03) and higher incidence of hypophosphatemia.

More recently, the IDEAL-ICU trial was a multicenter, randomized, controlled trial comparing early vs. late initiation of RRT for patients with AKI and sepsis.[10] Inclusion criteria included patients ≥ 18 years of age, admission to the ICU with sepsis within 48 hours of the start of vasopressor therapy, and AKI defined by "failure" under the RIFLE criteria. The early intervention group started RRT within 12 hours of meeting inclusion criteria, while the delayed group were monitored for the development of criteria for emergency RRT, including potassium 6.5 mmol/L, pH < 7.15, or fluid overload refractory to diuretics. If any of these criteria were met, RRT was started as soon as possible. If none of these criteria were met, RRT was initiated 48 hours after the diagnosis of AKI (unless spontaneous renal recovery occurred, defined by spontaneous urine output > 1,000 mL per 24 hours or > 2,000 mL per 24 hours with diuretics). The choice of RRT was at the discretion of each site. The primary outcome was 90-day mortality. After the second planned interim analysis, the authors ended the trial for futility. There was no difference in 90-day mortality between groups.

Prior to the IDEAL-ICU trial, a systematic review and meta-analysis of both the ELAIN and AKIKI trials (as well as seven other randomized, controlled trials for a total of 1,636 patients) was published.[11] The definitions for AKI and early and delayed initiation varied. For overall mortality, there was no difference in early vs. late initiation of RRT (HR, 0.98; 95% confidence interval, 0.78-1.23). Similarly, ICU LOS and hospital LOS were similar in each group. There was no difference in renal recovery, dependence on RRT, duration of RRT, or time to renal recovery. However, there was a high degree of heterogeneity, and the authors warned these conclusions must be interpreted cautiously.

DISCUSSION

What guidance can we take from these mostly negative trials of early vs. late initiation of RRT? A few lessons can be learned from the similarities and differences in each trial. The most recent trials contained absolute criteria for the initiation of RRT. *(See Table 2.)* In general, patients with serum potassium > 6-6.5 mmol/L or with ECG changes, BUN > 100-112 mg/dL, or pH < 7.15 should be dialyzed emergently regardless of RIFLE or KDIGO stage. However, each trial had different RRT modalities, and it remains unclear whether continuous RRT or intermittent RRT is most appropriate.

The ELAIN trial was the largest positive trial. Several features of this trial deserve special attention. First, most patients were admitted for surgical indications. Of the 231 patients randomized, 108 were admitted for cardiac surgery, 78 for abdominal surgery, and 28 for trauma. In contrast, AKIKI primarily included medical patients, with only 20% of patients admitted for surgical indications. IDEAL-ICU focused on patients who met

Table 2. Absolute Indications to Start Renal Replacement Therapy in Each Trial

	ELAIN	AKIKI	IDEAL-ICU
Potassium	> 6 mmol/L	> 6 mmol/L	> 6.5 mmol/L
Urine Output	< 200 mL/ 12 hours	Anuria	Anuria
pH	None	< 7.15	< 7.15
Fluid Overload	Yes	Yes	Yes
Blood Urea Nitrogen	> 100 mg/dL	> 112 mg/dL	None
Other	ECG changes, magnesium > 4 mmol/L		

criteria for sepsis. Second, the inclusion criteria for ELAIN included elevated NGAL. This was intended to enrich the population for patients who would require RRT. Indeed, if one examines the proportion of patients in each study who underwent RRT, ELAIN was the highest, with 100% of the early arm and 91% of the late arm. *(See Table 3.)* In the AKIKI and IDEAL-ICU trials, only 51% and 62%, respectively, of the delayed arms ever underwent RRT, implying one-half to one-third of patients had spontaneous renal recovery. Third, the timing of initiation of RRT was much earlier in ELAIN than in the other trials. *(See Table 4.)*

The authors of these trials all started RRT in the early arm within four to eight hours of meeting criteria. However, the delayed arm in ELAIN started at a median of 25 hours, while AKIKI and IDEAL-ICU started at a median of 57 and 51.5 hours, respectively. The final key difference was the modality of RRT. ELAIN specified continuous venovenous hemodiafiltration, while the authors of the other studies allowed each participating site to make that decision.

With these features in mind, certain populations might benefit from early initiation of RRT. First, surgical patients without other medical complexities might perform better with earlier RRT. Ninety-day mortality in the early arm of the ELAIN trial was 39.3%, significantly lower than the early arms of the other trials (58% in IDEAL-ICU; 48.5% 60-day mortality in AKIKI). These patients simply may tolerate RRT better. Second, early initiation likely works best for patients who will need RRT so that the benefits outweigh the risks. In ELAIN, 100% and 91% of the early and late arms, respectively, received RRT. In contrast, in the late arm of AKIKI and IDEAL-ICU, only 51% and 62% required RRT, respectively. Thus, many patients in the early arms of these two trials may never have required RRT and, thus, no benefit was achieved. Third, early interventions for AKI may prevent organ dysfunction. ELAIN initiated RRT much earlier than AKIKI and IDEAL-ICU. *(See Table 4.)* These latter trials may have missed the window. Initiating RRT 57 hours (AKIKI) and 52.5 hours (IDEAL-ICU) after meeting criteria for renal failure may havemay have been too late to achieve benefit. Finally, it is notable that the largest positive trial clearly specified continuous venovenous hemodiafiltration at very specific flows and pump rates, while the negative trials were more heterogeneous.

Table 3. Number of Patients Receiving Renal Replacement Therapy in Each Arm of Each Trial

	ELAIN	AKIKI	IDEAL-ICU
Early	112 of 112	305 of 311	239 of 246
Late	108 of 119	157 of 308	149 of 242

Table 4. Median Time in Hours to Initiation of Renal Replacement Therapy (Interquartile Range)

	ELAIN	AKIKI	IDEAL-ICU
Early	6 (4-7)	4.3 (2.7-5.9)	7.6 (4.4-11.5)
Late	25 (18.8-40.3)	57 (25-83)	51.5 (34.6-59.5)

CONCLUSION

The optimal time for initiating RRT in patients admitted to the ICU remains uncertain. For most patients, there is no clear difference in mortality between early and delayed initiation. However, patients admitted for strictly surgical indications did demonstrate a benefit for earlier RRT. As we become better at predicting which patients will need RRT, early initiation may be beneficial for those patients specifically. Otherwise, there does not seem to be harm in delaying RRT until absolute indications for RRT are met. ■

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ABSTRACT & COMMENTARY

Medication Errors When Patients Transition Out of ICU

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Dr. Hammond reports no financial relationships relevant to this field of study.

SYNOPSIS: Three factors associated with decreased odds of an error occurring were daily patient care rounds in the ICU, discontinuing and rewriting medication orders during the transition of care from the ICU to a non-ICU setting, and 16-20 ICU beds in the transferring ICU.

SOURCE: Tully AP, et al. Evaluation of medication errors at the transition of care from an ICU to non-ICU location. *Crit Care Med* 2019;47:543-549.

Medication errors may occur at any point during a patient's hospitalization, although transition points from different levels of care (e.g., ED to ICU, ICU to floor, and floor to outpatient setting) add an additional element of potentiating the error until the patient's next formal interaction with a healthcare provider.[1,2] The financial costs and mortality attributable to these errors in the United States represent at least $19.5 billion and 98,000 deaths, respectively.[3] Guidelines and best practice statements for transition of care (TOC) focus predominately on hospital discharge, which has many similarities but also differences compared to an inpatient TOC.[4,5] The extent to which medication errors occur during the TOC from the ICU to a lower acuity inpatient setting and risk factors associated with development or prevention of those errors has not been described.

Tully et al completed a multicenter, observational, seven-day, study of patients' first transfer from an ICU to a non-ICU setting within the same institution to describe the point prevalence and types of medication errors and patient-, medication-, and system-specific factors associated with their development.[6] A pharmacist evaluated medication orders that were active within one hour pre- and post-ICU transfer for potential medication errors. These pharmacists were provided training and reference documents to facilitate valid and reliable identification of potential medication errors. Prevalence and characteristics of errors were determined using descriptive statistics. Characteristics between those TOCs with and without a medication error were compared. Characteristics with a *P* value < 0.05 were considered for inclusion in a multivariate logistic regression analysis to determine independent risk factors for medication errors at TOC.

Of the 985 TOCs evaluated, 450 had at least one medication error. Most patients experienced a single error (55.1%), although the mean number of errors was 1.88 (standard deviation, 1.30; range, 1-9). The most common error types were continuation of a medication with an ICU-specific indication (28.4%), untreated condition (19.4%), and medication without a clear indication (11.9%). The most common untreated conditions were cardiac (27.6%) or neurologic (12.9%) in nature. Three-quarters of errors reached patients, although 94.2% did not cause patient harm. For those errors that did cause patient harm, the most common types of errors were incorrect dose (22.6%) and untreated condition (18.9%), and medication classes were anti-infective (28.6%), cardiovascular (18.4%), and neurologic (12.2%). Patient-specific factors associated with increased odds of medication errors were renal replacement therapy during ICU stay (odds ratio [OR], 2.93; 95% confidence interval [CI], 1.42-6.05) and number of medications ordered following TOC (OR, 1.08; 95% CI, 1.02-1.14). Medication-specific factors associated with increased odds of medication errors were receipt in the ICU of an anti-infective agent (OR, 1.66; 95% CI, 1.19-2.32), hematologic agent (OR, 1.75; 95% CI, 1.17-2.62), and intravenous fluid, electrolyte, or diuretic agent (OR, 1.73; 95% CI, 1.21-2.48). System-specific factors associated with increased odds of medication errors were community teaching hospital (OR, 3.96; 95% CI, 1.79-8.79) and 500-999 total inpatient hospital beds (OR, 4.26; 95% CI, 1.05-17.32). System-specific factors associated with lower odds of medication errors were daily patient care rounds in the ICU (OR, 0.15; 95% CI, 0.007-0.34), discontinuing and rewriting medication orders during the TOC from the ICU to a non-ICU setting (OR, 0.36; 95% CI, 0.17-0.73), and 16-20 ICU beds in the transferring ICU (OR, 0.40; 95% CI, 0.21-0.74).

■ COMMENTARY

Medication errors occur in almost 50% of patients transitioning from the ICU to a non-ICU setting. While all errors placed patients at an increased risk for harm, approximately 5% resulted in patient harm during the hospitalization. The quantity and extent of harm from these errors likely are underestimated for at least three reasons. First, errors that were recognized and resolved during order verification likely were underreported because the data collection process was more complex

for capturing and recording these types of errors. Additionally, the duration errors persisted, including presence of the error at hospital discharge, was not evaluated. Because of the retrospective nature of this research, interventions to resolve these errors were unable to be provided after they were identified. Finally, there was at least one dedicated pharmacist for each ICU from which patients were transferred. Pharmacists frequently recognize and resolve minor and major medication errors.[7,8] However, approximately one-third of ICUs in the United States do not employ a partially or fully dedicated pharmacist.[9] The quantity and harm from medication errors at institutions without dedicated ICU pharmacist services likely is greater than reported in this research.[7]

The three factors associated with lower odds of an error were system- and process-focused in nature and represent opportunities for improving patient safety while also likely improving other financial and patient care metrics.[10] While implementing or improving the structure and formality of direct patient care rounds is a significant undertaking, the benefits can be substantial.[10] Similarly, reducing the size of the critical care service to accommodate 16-20 patients at most may require additional resources but likely will increase the ability of all members of the healthcare team to adequately provide care for these patients. The final factor (discontinuing and rewriting medication orders during TOC) is straightforward to implement in most electronic health records and TOC workflow processes.[11] The research by Tully et al may serve as both a call to action for institutions that are at an increased risk for medication errors and a trove of hypothesis-generating data for investigators interested in improving patient safety through process changes. ■

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ABSTRACT & COMMENTARY

Efficacy of Preoxygenation Methods Prior to Endotracheal Intubation

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Dr. Sharma reports no financial relationships relevant to this field of study.

SYNOPSIS: A post-hoc analysis of data from the MACMAN trial revealed noninvasive ventilation may be the preferred preoxygenation approach for intubation, especially in the setting of severe hypoxemia.

SOURCE: Bailly A, et al. Compared efficacy of four preoxygenation methods for intubation in the ICU: Retrospective analysis of McGrath Mac Videolaryngoscope versus Macintosh Laryngoscope (MACMAN) trial. *Crit Care Med* 2019;47:e340-e348.

The authors of the McGrath Mac Videolaryngoscope Versus Macintosh Laryngoscope (MACMAN) trial randomized critically ill patients undergoing endotracheal intubation to video laryngoscopy (VL) and direct laryngoscopy (DL) using a Macintosh (curved) blade. Bailly et al analyzed the four groups retrospectively for outcomes with respect to preoxygenation technique: bag valve mask (BVM) ventilation using oxygen at 15 L/minute flow (no positive-end expiratory pressure [PEEP] valve was used) for three minutes, nonrebreather (NRB)

mask with oxygen at 15 L/minutes for three minutes, noninvasive ventilation (NIV) with 100% oxygen for at least three minutes, and high-flow nasal cannula (HFNC) oxygen (Optiflow) at 60 L/minute flow at 100% FiO_2 for three minutes. Intubators were free to choose any one of the four methods. The association of nadir pulse oximetry (SpO_2) during endotracheal intubation and two hours after intubation with the preoxygenation technique was the primary objective of the study. The secondary objectives included assessment of risk factors for SpO_2 below 80%, 90%, and a composite endpoint of cardiac arrest; systolic blood pressure (SBP) < 90 mmHg; or SpO_2 below 80%. During the study, standardized forms collected data, including primary diagnosis, duration of preoxygenation, duration of endotracheal intubation, baseline SpO_2, and baseline PaO_2/FiO_2 ratio.

Models to assess factors associated with the median minimal SpO_2 during intubation and two hours postintubation were identified. Logistic regression analysis models were created to identify factors associated with SpO_2 < 80% and < 90% across the four preoxygenation groups (BVM, NRB mask, NIV, and HFNC), with BVM serving as the index. Multiple logistic regression analyses were performed to identify factors associated with major complications (esophageal intubation, cardiac arrhythmias, dental injuries) and serious complications (death, cardiac arrest, SpO_2 < 80%, and SBP decline to < 90 mmHg).

Overall, 319 patients were included in the analysis (44 patients of the original MACMAN cohort were excluded due to multiple preoxygenation techniques used). All patients underwent rapid sequence intubation (RSI). The number of intubation attempts, duration of attempts to intubate, and proportion of intubation first attempts by a nonexpert were no different across groups. Clinical characteristics of patients in each group were similar, except for a higher proportion of patients with severe hypoxemia at baseline and those intubated for a primary respiratory diagnosis in the NIV group. While the duration of preoxygenation was longer in the NRB, NIV, and HFNC groups vs. the BVM group, it did not seem to affect the extent of drop in SpO_2 around intubation. Severity of illness scores (based on Simplified Acute Physiology Score [SAPS] II) and baseline SpO_2 were significant predictors of minimal SpO_2 value during endotracheal intubation plus two hours after intubation.

More attempts at intubation were associated with greater declines in SpO_2 levels during intubation and in the hours following intubation. Regardless of preoxygenation technique used, baseline SpO_2 was predictive of how far the SpO_2 would drop during and subsequent to intubation. Provision of NIV was associated with an adjusted odds ratio (aOR) of 0.10 with respect to BVM when predicting an SpO_2 drop below 90% (implying a "protective" effect). HFNC was worse than BVM (aOR for hypoxemia, 5.75). Provision of a NRB mask had an aOR similar to BVM.

■ COMMENTARY

The authors of this retrospective analysis concluded that NIV was the most efficacious preoxygenation technique, especially for those patients with significant hypoxemia to begin with. This study comes with all the drawbacks of a post-hoc analysis, which have been well-described — namely, discovering a finding that occurs purely by chance. The authors did not detail assessment of heterogeneity of treatment differences (however, they acknowledged the groups were heterogeneous). The authors further acknowledged that the study is underpowered for some treatment effects, needing 526 patients to provide > 90% power. Most importantly, preoxygenation devices were not allocated in randomized fashion. Keeping these limitations in perspective, this study demonstrated the (likely) superiority of NIV as a preoxygenation technique and confirms my practice in preoxygenating patients in the ICU.

Bailly et al did not suggest NIV settings, and these were not standardized in the MACMAN trial and were left to the discretion of the intubating physician. The duration of preoxygenation did not seem to affect the extent of the drop in SpO_2 across groups, which if confirmed in a clinical trial, would help inform the preintubation check list. Multiple attempts at intubation were associated with greater drops in SpO_2, not just during intubation but also in the hours following intubation. This speaks to the importance of avoiding critical desaturation during intubation and choosing the most efficacious preoxygenation technique, especially in those with lower baseline SpO_2. As noted above, NIV settings were not standardized, but typically aimed for exhaled tidal volume of 7-10 mL/kg and PEEP of 5 cm H_2O. Higher levels of PEEP may be prudent for clinically greater ventilation/perfusion mismatch or intrinsic PEEP.

Baseline hypoxemia and severity of illness affected the severity of hypoxemia during endotracheal intubation, regardless of preoxygenation technique used. However, in this analysis, baseline hypoxemia was more severe in the NIV group, suggesting that NIV may be the preferred preoxygenation technique for sicker patients with worse baseline SpO_2. This analysis also underlines the importance of ensuring that intubation is achieved with the fewest attempts possible and the need for a clear plan for those with significant hypoxemia despite adequate preoxygenation.

The results of a small randomized trial (n = 52) suggests that NIV is superior to BVM with oxygen, but larger trials are needed to confirm this finding (one is ongoing).[1,2] In the interim, provision of NIV as a preoxygenation technique for the sickest patients with the worst hypoxemia at baseline seems prudent. ■

REFERENCES

1. Baillard C, et al. Noninvasive ventilation improves preoxygenation before intubation of hypoxic patients. *Am J Respir Crit Care Med* 2006;174: 171-177.
2. Frat JP, et al. Preoxygenation with non-invasive ventilation versus high-flow nasal cannula oxygen therapy for intubation of patients with acute hypoxaemic respiratory failure in ICU: The prospective randomised controlled FLORALI-2 study protocol. *BMJ Open* 2017;7:e018611.

CME/CE INSTRUCTIONS

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CME/CE QUESTIONS

1. Randomized, controlled trials of early vs. late initiation of renal replacement therapy (RRT) demonstrated:
a. benefit in all patients.
b. benefit in patients with chronic kidney disease.
c. mixed results, although most trials did not demonstrate benefit.
d. no difference in mortality in any patient group.

2. Which of the following is an absolute indication to start RRT in clinical trials of early vs. late initiation of RRT?
a. pH > 7.15
b. Potassium < 6-6.5 mmol/L
c. Blood urea nitrogen < 100-112 mg/dL
d. Anuria

3. In the study by Tully et al, what percentage of patients who transferred from an ICU to a non-ICU setting within the same institution had at least one medication error occur during the transition of care (TOC)?
a. 15.7%
b. 25.7%
c. 35.7%
d. 45.7%

4. In the study by Tully et al, which factor was associated with lower odds of a medication error occurring during TOC?
a. A total of 500-999 inpatient hospital beds
b. Community teaching hospital
c. Discontinuing and rewriting medication orders during the TOC from the ICU to a non-ICU setting
d. Number of medications ordered following TOC

5. Which preoxygenation technique is associated with the lowest risk for a drop in pulse oximetry (SpO_2) around the time of intubation?
a. Noninvasive ventilation
b. Bag valve mask ventilation
c. Nonrebreather mask
d. High-flow nasal cannula oxygen

CME/CE OBJECTIVES

Upon completion of this educational activity, participants should be able to:

- identify relevant topics in the practice of critical care medicine;
- utilize recommendations from current clinical guidelines; and
- manage common critically ill patient and ICU administration scenarios.