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CRITICAL CARE ALERT™

A monthly update of developments in critical care and intensive care medicine

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Measuring PA Wedge Pressure: Nurses vs. Doctors

ABSTRACT & COMMENTARY

The goal of this study was to determine whether there were inter- and intraobserver differences in measures of pulmonary artery occlusion (wedge) pressure (Ppao) made by physicians vs. critical care nurses (CCNs) and, if differences were found, to determine what factors influenced this variability. Over a one-year period, CCNs were asked to obtain a paper tracing twice a day at the same time that they recorded Ppao values using the bedside monitor. The tracings were labeled by a single individual, who indicated the mode of ventilation and also assessed each tracing for the presence of ventricular waves, defined as phasic increases in Ppao of 4 mmHg or more that corresponded to the shock therapy (ST) interval of the electrocardiogram (ECG), and also measured the respiratory phasic variation (RPV) of all Ppao tracings, defined as the maximum-minimum value on each tracing. The two physicians (chief of critical care [CCMD] and chief of cardiology [CARD]) independently interpreted each tracing on two separate occasions, in blinded fashion, and these values were compared with CCN values.

During the study interval, 147 measurements of Ppao were performed on 40 patients with a mean age (+ SE) of 62.5 ± 2.2 years and a mean APACHE II score of 21.5 ± 0.8. Thirty-four readings were excluded from analysis because the tracings did not contain an appropriate Ppao tracing (n = 28) or were mislabeled (n = 6). Of the tracings (n = 113) interpreted for the study, 96 were obtained during positive pressure ventilation and 17 were obtained during spontaneous ventilation. Agreement between the two physicians, determined by correlation coefficients, was 0.91 for the CCMD and 0.87 for the CARD. Agreement between different observers was 0.83 for CCMD-CARD, 0.66 for CARD-CCN, and 0.67 for CCMD-CCN. Differences between the physicians and nurses for 95% of the readings (limits of agreement) ranged from -5.3 to 7.3 mmHg (CCMD-CARD) to -9.2 to 7.6 mmHg (CARD-CCN).

Neither the use of positive pressure ventilation nor the presence of ventricular waves in the Ppao tracing predicted physician-nurse or physician-physician disagreement in measurement. However, differences for tracings with RPV more than 8 mmHg

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were significantly greater than for tracings with variations less than 8 mmHg ($P < 0.05$, except for CCMD-CCN, $P = 0.10$). As a final step, three tracings (1 with no RPV, 2 with large RPV) were presented to a convenience sample of 23 CCN and 18 physicians (8 board-certified cardiologists, 4 board-certified critical care physicians, and 6 cardiology or pulmonary fellows). All but one nurse and one fellow identified the Ppao within 4 mmHg of the mean value for the tracing with minimal RPV. For the two tracings with a larger RPV, variability was twice that observed for the tracing with minimal RPV. (Al-Kharrat T, et al. *Am J Respir Crit Care Med* 1999;160:415-420.)

COMMENT BY LESLIE A. HOFFMAN, PhD, RN

This study demonstrates the presence of significant differences in the measurement of Ppao tracings among physicians and between physicians and CCNs when tested in a clinical practice setting. As such, findings confirm those obtained from prior studies that have described significant observer variability in Ppao measurement when tested using a questionnaire format. In this study, values recorded by 50 nurses with varied experience in critical care were compared to those reported by two physicians with extensive experience in critical care. Despite these differences in sample size, nurse-physician differences were not substantially greater than physician-physician differences.

The major explanation appeared to be related to two factors: different methods of identifying end-exhalation and large RPV. The CARD identified end-exhalation on the basis of ventilator status. For patients on mechanical ventilation, he chose end-exhalation as the trough values of Ppao. When patients were breathing spontaneously, he chose peak values of Ppao. In contrast, the CCMD determined end-exhalation by combining knowledge of ventilator status and examining RPV, assuming that exhalation is usually longer than inhalation. For ventilated patients with large RPVs, he chose the peaks for Ppao interpretation if the peaks were of longer duration than the troughs.

Thus, some of the variability appeared to be related to different methods of identifying end-exhalation. Criteria used by the CCNs were not identified in the article, although Al-Kharrat and colleagues indicated that the nursing department provided extensive training, with annual skill evaluation. Standard practice used by the CCNs to determine Ppao involved adjusting the on-screen horizontal axis (cursor) tangential to the point on the Ppao tracing believed to be end-exhalation. A digital Ppao reading was then displayed and recorded on the patient's chart.

Because nurses who participated in this study were recruited from the medical and cardiac intensive care units (ICUs), it is likely that nursing staff of the two units used different criteria for identifying end-exhalation, similar to the CARD and CCMD. In addition, there was substantial variability when physicians and nurses interpreted tracings with large (> 8 mmHg) RPV, most likely due to difficulty in identifying end-exhalation.

These findings are important because they identify two variables that can affect Ppao readings, both of which can potentially be influenced through education. Critical care practitioners can be taught strategies to increase accuracy when there are large RPV, such as examination of tracings for respiratory phasic cycle lengths, and using this analysis to more accurately identify end-exhalation. If large RPV are present, this factor should be noted when reporting Ppao values, since the likelihood of error appears to be greater. Such information is important because inaccurate interpretation of Ppao can lead to incorrect management decisions, including failure to treat or inappropriate treatment. ❖

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Predicting ICU Readmission After Cardiac Surgery

ABSTRACT & COMMENTARY

Synopsis: *Patients most likely to be readmitted to the ICU were those with the longest time in the ICU prior to discharge. The most common reason for readmission was pulmonary problems.*

Source: Cohn WE, et al. *Chest* 1999;116:688-692.

To evaluate factors that increase the likelihood of intensive care unit (ICU) readmission, Cohn and colleagues surveyed 2388 consecutive patients who underwent cardiac surgery at their institution from 1994-1997. Patients were excluded from analysis if they died during surgery (n = 15), in the ICU (n = 87), or when available data were incomplete (n = 58), yielding a final sample of 2228 patients. Of these patients, 128 were readmitted to the ICU. One investigator who identified the single most prominent reason for ICU readmission reviewed the discharge summary of each patient readmitted to the ICU.

Over the four-year period, ICU stay decreased (P = 0.048), but ICU readmission as a percentage of discharges increased from 3.9% (1994) to 8.4% (1997) (P = 0.005). When patients readmitted to the ICU were divided into four equal groups based on their initial ICU length of stay (LOS; 1 = shortest; 4 = longest), the incidence of readmission was 3.9%, 5.2%, 4.7%, and 9.2%, respectively. Patients who required readmission had a longer (P = 0.008) mean initial ICU LOS as compared with those who did not require readmission. "Long stay" patients also had a longer secondary stay compared with "short stay" patients.

Preoperative factors associated with a greater likelihood of ICU readmission included a history of congestive heart failure (P = 0.0001), lower left ventricular ejection fraction (P = 0.0080), female gender (P = 0.019), and more than three comorbidities. Postoperative and intraoperative factors associated with increased likelihood of ICU readmission included a greater weight gain during ICU stay (P = 0.038), longer initial ventilator time (P = 0.038), and homologous blood use in the operating room (P = 0.045). Three factors accounted for 75% of all readmissions: respiratory problems (40.6%), dysrhythmias (21.1%), and the need to return to the operating room (13.3%). The percentage of patients readmitted for pulmonary problems rose from 1.5% (1994) and 0.9% (1995) to 3.2% (1996) and 3.0% (1997) (P= 0001).

COMMENT BY LESLIE A. HOFFMAN, PhD, RN

This study was prompted by a review on the part of the cardiac surgical team that indicated an apparent increase in the return of patients to the ICU after an initial discharge. This observation raised concerns that the decrease in post-cardiac surgery ICU LOS prompted by managed care had adversely affected patient outcomes. However, the central finding of the study was that patients most likely to return to the ICU were those with the longest stay, not those with the shortest stay.

Patients in this sample seemed typical of those individuals who require cardiac surgery: mean age was 65 ± 11.8 years, 32.4% were female, and 73.8% underwent coronary artery bypass grafting. However, no further information was given regarding preoperative health status. Patients were managed by one group of cardiac surgeons, with transfer to a surgical ICU staffed by surgical and anesthesiologist intensivists. After their ICU stay, patients were transferred to a dedicated rehabilitation unit with telemetry. ICU discharge was protocol-based, not time-based, and there was no evidence that unit capacity caused premature discharge.

Although many predictive factors identified in this study are not amenable to intervention, there were some notable exceptions. Patients who required ICU readmission were likely to have a greater mean weight gain while in the ICU (10.3 ± 4.7 kg vs 8.5 ± 5.6 kg), and longer time on mechanical ventilation. In almost half the cases, the reason for ICU readmission was a pulmonary problem which developed on the clinical unit. No information was given regarding stability of the nurse:patient ratios or respiratory care staffing during the four-year data collection interval. One of the many consequences of managed care has often been a decrease in the number of nurses and respiratory therapists available to manage the care of acutely ill patients, combined with an increase in patient severity of illness. We have substantially decreased ICU LOS for most cardiac surgery patients without adverse outcomes.

As Cohn et al note, the next challenge is to devise management strategies targeted at patients at high risk for ICU readmission that might prevent the need for readmission or, at the least, decrease the overall length of ICU stay. One method of accomplishing this goal is analysis of the extensive data in databases to determine causes of the problem. Another method involves testing innovative solutions. Kirby and Durbin (*Respir Care* 1996;41:903) tested the effect of a dedicated respiratory therapy assessment team for non-ICU patients that visited all patients prior to and following ICU discharge. The team was successful in reducing mortality of readmitted patients and the proportion of patients readmitted for

respiratory failure. Broader testing of this and other creative solutions is needed to help patients at highest risk bridge the critical interval between ICU discharge and recovery. ❖

NPPV in Acute Lung Injury?

ABSTRACT & COMMENTARY

Synopsis: *Although six of 12 patients with acute lung injury or acute respiratory distress syndrome were successfully managed with noninvasive ventilatory support in this case series, broad application of these results in other practice settings may be inappropriate.*

Source: Rocker GM, et al. *Chest* 1999;115:173-177.

This paper describes the use of noninvasive positive-pressure ventilation (NPPV) in an anecdotal series of 12 episodes of ventilatory support in 10 patients with acute hypoxemic respiratory failure. NPPV was delivered via full-face mask using a Puritan Bennett 7200a ventilator in the pressure support mode. The patients were managed in the intensive care unit (ICU) of a tertiary referral center and university hospital in Nova Scotia, Canada.

The patients ranged in age from 25 to 89 years, and all were hemodynamically stable. Eight of 10 patients had medical disease (aspiration, bacteremia, fungemia, malaria, fat emboli, post-bone-marrow transplant, thrombotic thrombocytopenic purpura, and near-drowning); the other two patients had trauma (not otherwise specified) and burns with inhalation injury, respectively. APACHE II scores for the 10 patients averaged 16 (range, 11-29); their PaO_2/FIO_2 ratios prior to NPPV ranged from 50-277 mmHg (mean, 102). Two patients had two episodes of NPPV each. Rocker and colleagues state the European-American diagnostic criteria for acute lung injury (ALI) or the acute respiratory distress syndrome (ARDS), although on two occasions only two thoracic quadrants were involved radiographically. Three patients died.

On nine occasions NPPV was used as the initial method of ventilatory assistance, and in six of these instances intubation was not required. NPPV was applied following planned (1) or unplanned (2) extubation in the other instances, and was unsuccessful in each case. Thus, NPPV was successful in six of 12 attempts in these patients. Rocker et al conclude that this is "a surprisingly high success rate" and recommend that this approach to ventilatory support "be considered for patients in stable condition in the early phase of ALI/ARDS."

COMMENT BY DAVID J. PIERSON, MD, FACP, FCCP

NPPV is now the standard of care for acute ventilatory failure due to exacerbations of chronic obstructive pulmonary disease (COPD), and it has also achieved good success in acute-on-chronic ventilatory insufficiency among patients with kyphoscoliosis and other neuromuscular or musculoskeletal disorders in which upper airway function is preserved. Similarly, both NPPV and continuous positive airway pressure (CPAP) have been found to be effective in avoiding invasive mechanical ventilation in patients with congestive heart failure with acute pulmonary edema. However, although there are anecdotal reports of the successful use of NPPV in acute severe asthma, these reports have been viewed skeptically by experienced clinicians and NPPV has seen little use in that setting.

This report suggests that NPPV may also have a role in managing patients with ALI/ARDS. I would take that conclusion with more than a few grains of salt, not because I doubt the veracity of Rocker et al's report, but because of concerns about the generalizability of this small experience in a specific patient population.

In the county hospital and level 1 trauma center in which I practice, approximately 100 patients meet the European-American diagnostic criteria for ARDS each year. Half of these patients have multiple trauma, and half of the rest have nontraumatic surgical disease. Of the nonsurgical patients who develop ARDS, most have severe sepsis, overwhelming pneumonia, or drug overdose as their predisposition to the syndrome. In a practice environment with an aggressive prehospital rescue and transport system, most such patients are intubated in the field, in the emergency room, or in the operating room prior to arrival in the ICU. In my practice setting then, opportunities to manage patients with ALI/ARDS noninvasively are infrequent.

Although I believe it is important to place reported experiences such as those in this paper in the proper context of one's own practice, I also agree that there are some patients in whom an attempt at NPPV would seem reasonable. As Rocker et al state, these would be patients with single-organ failure, who are hemodynamically stable, and in whom the duration of ventilatory support can be expected to be fairly brief. Such patients should be managed in an ICU setting, where appropriate monitoring can be carried out and the transition to invasive mechanical ventilation can be made promptly and safely if need be. ❖

A Blood Test for Susceptibility to Septic Shock?

ABSTRACT & COMMENTARY

Synopsis: *TNF2, a specific polymorphism within the tumor necrosis factor-alpha gene promoter, was found more often in the blood of patients with septic shock than in healthy blood donors. Patients with the TNF2 allele were 3.7 times more likely to die than patients without this finding.*

Source: Mira JP, et al. *JAMA* 1999;282(6):561-568.

The cytokine tumor necrosis factor-alpha (TNF-α) is believed to be involved in the pathogenesis of septic shock. A polymorphism within the TNF-α gene promoter called TNF2 has been shown to be associated with enhanced TNF-α production and also with worse clinical outcomes in certain types of severe infections. This multicenter European study sought to determine the frequency with which the TNF2 allele was present in the blood of patients with clinical septic shock, and also whether it was associated with mortality.

Blood was drawn from 89 patients with septic shock and also from 89 healthy unrelated blood donors. Mira and colleagues determined the frequency of the TNF2 allele and also the levels of TNF-α in the blood, and correlated these findings with the patients' clinical outcomes. All the patients required mechanical ventilation, and 54% of them died. The polymorphism frequencies of the controls and the patients with septic shock differed significantly at only one allele—TNF2 (18% vs 39%; P = 0.002). The frequency of the TNF2 allele was 52% among septic shock patients who subsequently died, as compared to 24% among those who survived (P = 0.008). The concentrations of TNF-α in the blood of patients with the TNF2 allele vs. a comparison allele were not statistically different. By multiple logistic regression analysis of the data after controlling for age and the probability of death by SAPS II score, patients with the TNF2 allele were 3.7 times as likely to die than patients lacking the allele (95% confidence interval, 1.37-10.24-fold increased risk of death).

COMMENT BY DAVID J. PIERSON, MD, FACP, FCCP

This study showed an increased frequency of a particular identifiable genetic polymorphism, TNF2, in patients with septic shock. Further, it found that, among patients with septic shock, those with the allele in question were 3.7 times more likely to die than those without it. Although testing for TNF2 is not clinically available, and would be unlikely to help in the management of an individual patient at this point, this study raises some exciting possibilities. One is that it may one day be possible to develop specific therapies to prevent or counteract the effects of the TNF2 allele, modifying the individual's susceptibility to and clinical manifestations of septic shock. Another, admittedly remote, possibility is that, as genetic testing becomes more practical and encompasses ever larger portions of the human genome, we may be able to assemble a genetic profile on an individual at birth that could be used to identify susceptibilities and tailor therapies to a variety of diseases throughout that person's life. ❖

Writing DNAR Orders: A Frequently Missed Opportunity

ABSTRACT & COMMENTARY

Synopsis: *Among medical patients admitted to an acute-care ward who were judged by an expert panel to be appropriate for do-not-attempt resuscitation (DNAR) orders, more than half did not have such orders written. Attending physicians offered several reasons for not writing DNAR orders, although they claimed not to be uncomfortable with or morally opposed to them.*

Source: Eliasson AH, et al. *Arch Intern Med* 1999;159: 2213-2218.

In this study from walter reed army medical center, Eliasson and colleagues sought to determine whether orders not to attempt resuscitation (DNAR) were written when appropriate and, when they were not, the reasons for not writing them. Eliasson et al reviewed the records for all admissions to the general medicine service during a four-month period. After the patients were discharged from the hospital, a five-member panel determined whether DNAR orders were indicated using a screening tool consisting of features of different diagnoses that suggested a poor prognosis. When the panel's assessment was that a DNAR order was indicated, and no such order had been written during the hospital stay, one of the investigators interviewed the patient's attending physician to determine the factors that had interfered with the writing of the DNAR order.

There were 613 admissions to the medical service during the study period. Of these, 149 (24%) were judged to merit a DNAR order, but in 88 of these patients (59%) DNAR orders were lacking. Absence of a DNAR order did not correlate with patient age, gender, or race.

The three most common reasons given by attending physicians for not having written a DNAR order during the patient's hospitalization were: 1) the belief by the attending physician that the patient was unlikely to die during this hospitalization (in 56% of patients); 2) the belief that the patient's primary physician should discuss DNAR issues with the patient (46%); and 3) the lack of an appropriate opportunity to discuss end-of-life issues with the patients or their family (43%). In 12% of the cases, patients or their families did not accept a physician's recommendation for a DNAR order. None of the attending physicians stated that moral objections to a DNAR order, medical-legal considerations, or personal discomfort with discussing the topic played a role in their failure to write a DNAR order during their patient's stay.

COMMENT BY DAVID J. PIERSON, MD, FACP, FCCP

This study shows that, at Eliasson et al's institution, DNAR orders were often not written when an expert panel felt in retrospect that they should have been. It also shows that physicians cite several different reasons for not writing DNAR orders, including the belief that the illness "wasn't serious enough," not being familiar enough with the patient to broach the issue, and the conviction that discussing end-of-life issues with the patient was "someone else's job." I suspect that these findings are representative of physician behavior at other institutions as well.

Although the Patient Self-Determination Act mandates that everyone admitted to the hospital be offered the opportunity to make a living will and to make known their wishes for attempted resuscitation, this act has had little affect, and the majority of patients do not make such wishes known to their physicians. The present study and others have also shown that physicians tend not to seize the opportunity to discuss end-of-life issues with their patients or, when appropriate, to write DNAR orders. This was a study of general medical ward patients, not of patients admitted to an ICU. Because the majority of patients who die in ICUs have life support withheld or withdrawn, it appears that physicians are less reluctant to discuss these issues with patients or their families at times of more obviously life-threatening illness.

Nonetheless, for patients with medical illnesses serious enough for a DNAR order to be "indicated," according to the five-member expert panel in this study, such orders were written less than half the time. It is symptomatic of the fragmentation of contemporary medicine that inpatient attending physicians often felt that they did not know their patients well enough to discuss DNAR status, or considered such discussions the job of others in the health care system. Finding ways around these and the other obstacles to appropriate discussions of end-of-life issues that were identified in this study is a difficult but important challenge for the future. ❖

Special Feature

Gastric Tonometry—Research Toy or Clinical Tool?

By Charles G. Durbin, Jr., MD, FCCM

Since the early 1980s, scientists have used semipermeable, saline-filled balloons equilibrated in the stomach to estimate gastric mucosal pCO_2, calculate mucosal pH, and identify inadequate intestinal perfusion. It is hypothesized that inadequate intestinal perfusion reflects incomplete resuscitation or inadequate cardiac output. If ischemia persists long enough, release of gut toxins can lead to the systemic inflammatory response syndrome (SIRS) and multiple organ system failure (MOSF). Gastric tonometry has been suggested as a minimally invasive technique to detect and possibly prevent these prominent causes of intensive care unit (ICU) morbidity and mortality.

This brief essay reviews the information that has accumulated on the technique of gastric tonometry during the past decade. Unfortunately, initial enthusiasm for its routine use in the critically ill has not resulted in dramatically improved patient outcomes. Technical issues, patient selection, and timing of clinical interventions can influence the output and interpretation of this monitor. While gastric tonometry has been useful in increasing our understanding of the pathophysiology of MOSF, its inherent complexity suggests that it is not yet ready for routine clinical use.

Technique

Gastric tonometry is performed by placing a small, silastic balloon-tipped catheter in the stomach. Correct placement is usually confirmed by manometry, auscultation, catheter distance calculation, or radiography. The balloon is inflated with saline or other solution, which is allowed to equilibrate for 30-90 minutes, and then the

solution withdrawn. The pCO_2 is freely diffusible through the wall of the balloon and is assumed to reflect the mucosal pCO_2. The pCO_2 of the sample of fluid is measured in a conventional blood-gas analyzer; bicarbonate is calculated from an arterial blood gas sample, and, using the Henderson-Hasselbach relationship, mucosal pH (pH_i) is calculated.

The sample must be analyzed under strict anaerobic conditions. Some ABG analyzer systems produce inconsistent results with saline and should not be used for gastric tonometry. Histamine 2 (H_2) blockade seems to improve consistency. Equilibration time must be strictly maintained, and antacids must be avoided. Currently, only intermittent, labor-intensive measurements of pH_i can be made. These difficulties in measurement have prevented the technique from widespread adoption into the clinical environment. However, newer, semicontinuous, automated techniques are on the horizon.

Experimental Data on Efficacy

Is pH_i helpful in clinical care? Animal studies have confirmed the value of monitoring pH_i. Decreased pH_i accompanies hypovolemic, septic, and anaphylactic shock in various animal species. After resuscitation, a delay in return of pH_i confirms the sensitivity of mesenteric blood flow to shock states and supports the concept of the gut being the source of toxins. Studies in animals have shown that therapy directed at increasing cardiac output can raise pH_i to normal levels in mesenteric ischemia models.

In humans, results have been mixed. During abdominal aortic replacement surgery, pH_i fell less with hydroxyethyl starch than with crystalloid despite a similar cardiac output. In a study of critically ill patients, infusions of hydroxyethyl starch were superior to infusions of albumin in moderating decreases in pH_i. In one study, low-dose dobutamine was superior to red cell transfusions in raising pH_i in septic patients. In a study of bolus administration of fluids, no immediate effect was seen on pH_i. Several reports have suggested that dobutamine and dopeximine, but not epinephrine or dopamine, improve pH_i in critically ill patients.

In summary, changes in pH_i in response to clinical interventions are usually in the direction predicted; however, this is not uniformly the case. The rate of change of pH_i is delayed for several possible reasons. The measurement itself requires a long equilibration time and more rapid changes in mesenteric perfusion will not be detected as they occur. There may be specific measurement effects of some of the interventions that have little to do with actual bowel perfusion. In general, changes in pH_i related to clinical interventions are not fully understood and should not be used to replace clinical judgment.

Clinical Utility

What about outcome studies? There is no doubt that a low pH_i predicts a worse outcome in a variety of circumstances. The classic article by Gutierrez and colleagues demonstrated in a group of critically ill patients that a pH_i of less than 7.32 was associated with a higher mortality than those whose pH_i was more than 7.32. This predictive value of a low pH_i has been confirmed by many others. Chang and associates showed that a low pH_i 24 hours following resuscitation from trauma was the only factor that separated nonsurvivors from those who survived.

Complications following resuscitation, bowel or vascular surgery, or extracorporeal membrane oxygenator (ECMO) use are associated with a low pH_i. Complications and mortality are associated with a low pH_i following ruptured aortic aneurysm, during septic shock, and in critically ill trauma patients but not following liver transplantation. In some studies, pH_i was used to predict the likelihood of weaning from prolonged mechanical ventilation in chronic obstructive pulmonary disease (COPD) patients and the likelihood of developing septic complications in surgical ICU patients (but not survival).

The predictive value of pH_i is supported in most studies in which it is evaluated. Finding a low pH_i adds information that is not generally available from other patient assessment tools and monitors. However, most studies consist of few patients, and differences in methods of measurement and the definition of a low pH_i value make direct pooling of these studies difficult.

Can pH_i be Used to Improve Outcomes?

Have attempts directed at altering pH_i in a favorable way demonstrated improvement in outcome? So far this has not been fully supported with experimental human data. One large prospective study has been reported. Gutierrez et al reported on the use of a pH_i-driven protocol to prospectively treat ICU patients. Two hundred sixty patients were studied. Treatment group patients (n = 135) were aggressively managed if their pH_i was 7.35 or lower or if it fell by 0.1 pH units at any time during their ICU stay. In addition to optimizing oxygen delivery variables, filling pressures, and blood pressure, they were treated with volume infusions and, if necessary, dobutamine to return pH_i to 7.35 or above. Control patients were monitored with gastric tonometry but treatment of patients was left to the responsible clinician. Eighty-five percent of the treatment group received resuscitation directed by pH_i at some time during their ICU stay.

In this study, there was no overall difference in mor-

tality between the treatment and control groups. However, in those patients in whom the initial pH_i was normal, the treatment protocol resulted in improved survival (58% vs 42%). A second, small study in trauma patients demonstrated shorter length of stay and fewer complications when low pH_i was treated as compared to historical controls. There was no overall improvement in mortality.

Conclusions

Gastric tonometry has contributed to a better understanding of critical illness. It may be clinically useful in certain subgroups of critically ill patients. It seems to be helpful in managing patients who have normal mesenteric perfusion at the time monitoring is initiated. A low pH_i identifies a sicker group of patients who are at greater risk of death and complications. However, the technical problems and personnel demands make the use of this monitor unsatisfactory for most ICUs at the current time. Newer techniques may improve user friendliness but the value of the measurement needs further study demonstrating improved outcomes. ❖

CME Questions

19. The factor that caused the most variability in pulmonary artery pressure occlusion (Ppao) readings was:
a. large respiratory phasic variations.
b. level of practitioner training.
c. physician specialty.
d. years of ICU experience.
e. primary disease process of patient.

20. Noninvasive positive-pressure ventilation is the ventilatory support approach of choice in which of the following settings?
a. Status asthmaticus
b. Acute lung injury/acute respiratory distress syndrome
c. Acute ventilatory failure in chronic obstructive pulmonary disease
d. All of the above
e. None of the above

21. A factor that predicted the need for ICU readmission was:
a. patient age.
b. type of surgery.
c. mean weight gain in the ICU.
d. APACHE II score.
e. None of the above

22. Cardiac surgery patients most likely to be readmitted to the ICU had:
a. the shortest initial ICU stays.
b. the longest initial ICU stays.
c. intraoperative complications.
d. varying lengths of time in the ICU.

23. Reasons given by attending physicians for not having written a do-not-resuscitate order during the admission of a patient with serious medical disease include:
a. the belief by the attending physician that the patient was unlikely to die during this hospitalization.
b. the belief that the patient's primary physician should discuss CNAR issues with the patient.
c. the lack of an appropriate opportunity to discuss end-of-life issues with the patient or their family.
d. All of the above
e. None of the above

24. The most common reason given by attending physicians for not having written a do-not-resuscitate order during the admission of a patient with serious medical disease is:
a. a moral objection to the concept of DNAR orders.
b. fear of litigation.
c. personal discomfort with the subject.
d. All of the above
e. None of the above

25. Tumor necrosis factor-α is:
a. an antibody that blunts the body's response to infection.
b. a facilitator of phagocytosis by neutrophils that helps to control infection.
c. a cytokine believed to be involved in the pathogenesis of septic shock.
d. a new, genetically engineered vaccine against septic shock.
e. a naturally occurring antibacterial agent found in malignant tumors.

26. Which of the following is true about the TNF2 allele in septic shock?
a. Patients with the allele are less likely to die.
b. Patients with the allele produce less TNF-α than patients without the allele.
c. The allele confers immunity to development septic shock.
d. All of the above
e. None of the above

27. The accuracy of gastric tonometry is adversely affected by:
a. H_2 blockers.
b. antacid administration.
c. NG tube placed on suction.
d. agitation.
e. narcotic administration.

28. In gastric tonometry, a low pH_i predicts:
a. a higher change of survival.
b. failure of enteral nutrition.
c. a low serum albumin.
d. a higher rate of complications.
e. a positive response to dobutamine.

In Future Issues:

Outcome of Mechanical Ventilation in the Elderly
Procalcitonin in ARDS from Infection