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CRITICAL CARE ALERT™

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Therapeutic Paralysis: The Patient's Perception

ABSTRACT & COMMENTARY

Little is known about the experience of critically ill patients or family members when neuromuscular blocking agents (NMBAs) are used to achieve therapeutic paralysis. To better understand this experience, Johnson and colleagues interviewed 11 patients who received NMBAs while in a Level I trauma center and a family member for each patient who was present on a consistent basis while the patient was paralyzed. The patients spent 36.2 ± 21.7 days in the trauma ICU, including 33.2 ± 21.5 days on mechanical ventilation. The interviews were conducted after the patients were discharged from the ICU, but before hospital discharge. When interviewed, all patients had a Glasgow Coma Scale score of 15 and were oriented to person, place, and time. Mean age was 32.5 ± 12.0 years. NMBAs were administered for 13.1 ± 13.5 days and included pancuronium (n = 8), vecuronium (n = 2), or both drugs (n = 1).

When asked what they remembered, all patients described the experience with vagueness (e.g., "I was asleep for a long time and woke up"). Many patients had difficulty distinguishing dreams from reality (e.g., "I tried to tell people to do things, but they wouldn't do them in my dreams"). However, one patient described dreams that included details from conversations at the bedside. When asked about the experience of paralysis, none of the patients remembered being unable to move, being in pain, or specific events (e.g., procedures, alarms, or mechanical ventilation). However, some recalled hearing voices. Six patients recalled their mother talking to them and five recalled nurses talking to them (e.g., "I knew I could not move; my mom and my nurses told me"). When asked what could be done to make things better, family members stressed the importance of being informed about events, continuity of care (having the same nurses), and being told about the patient's reactions when paralysis was discontinued. Patients stressed the importance of having someone present to provide support, and not being tightly restrained. (Johnson KL, et al. *Am J Crit Care* 1999;8:490-498.)

COMMENT BY LESLIE A. HOFFMAN, PhD, RN

NMBAs induce paralysis, but do not alter consciousness, reduce pain, or relieve anxiety. Patients are left fully conscious but unable to

Volume 6 • Number 12 • March 1999 • Pages 89-96

INSIDE

move. Consequently, additional medications (e.g., analgesics and sedatives) must be administered when NMBAs are required. Few studies have attempted to document recollections of patients and family members about therapeutic paralysis. Consequently, little is known about the effectiveness of current approaches to manage pain and sedation during use of these drugs.

In this study, patients were interviewed approximately six days after ICU discharge. The interview included probes designed to prompt recollection of the experience. The patient and family member were asked to describe what the experience was like and to share what they remembered about the experience. Most patients described the experience with vagueness, as if they had been sleeping. Some patients recalled events, but they were unsure if they were real or part of a dream. In contrast to prior reports, patients in this study did not recall pain or relate any terrifying experiences while receiving NMBAs. Consequently, it appears that unit protocols were effective in managing pain and suppressing awareness of unpleasant events.

In this study, peripheral nerve stimulation (train-of-4) was used to ensure consistent and safe levels of blockade, and adequacy (3 of 4 twitches) was assessed every four hours. All patients received a loading dose and a maintenance dose of morphine or fentanyl. Morphine (5-30 mg/h IV) or fentanyl (300-1000 mcg/h/IV) was administered according to a schedule, not "as needed." In addition, all patients received lorazepam 2-4 mg IV every hour while on NMBAs. Thus, the protocols used a proactive approach for managing pain and sedation and suppressing awareness of unpleasant events. The unit had a liberal (24-hour access) visitation policy that encouraged family interaction.

Several findings of this study have important implications for health care providers. Frightening, painful experiences associated with the use of NMBAs may potentially be averted by protocols that entail monitoring the level of paralysis and schedule administration of medications to relieve pain, provide sedation, and decrease awareness. Because the patients were aware of being touched and of individuals present at the bedside, it is important to provide emotional support, explain procedures, and monitor what is said in bedside conversations. Critical care physicians and nurses should discuss the experience of therapeutic paralysis with patients to better understand how well protocols minimize adverse effects of this experience. ❖

When interviewed after withdrawal of neuromuscular blocking agents, patients recalled:

a. events vaguely, as if dreaming.
b. being on a mechanical ventilation.
c. being paralyzed and unable to move.
d. severe pain.
e. no events.

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Can Hyperoxia Overcome Hyperventilation-Induced Cerebral Ischemia?

ABSTRACT & COMMENTARY

Synopsis: *Jugular venous oxygen saturation (SjO_2) falls during hyperventilation, possibly reflecting a decrease in cerebral blood flow. Increasing the PaO_2 to greater than 200 torr during hyperventilation reversed the decline in SjO_2 in a group of severely head-injured patients.*

Source: Thiagarajan A, et al. *Anesth Analg* 1998; 87:850-853.

Hyperventilation is frequently used to control intracranial pressure in head-injured patients. The resulting decrease in cerebral blood flow may result in cerebral ischemia in normal brain areas and contribute to a worse patient outcome. Jugular venous oxygen satu-

ration (SjO_2) reflects the global balance between arterial oxygen delivery and brain oxygen uptake. It is often monitored in patients subjected to extreme hyperventilation and during vascular occlusive surgery.

Thiagarajan and colleagues studied the effect on SjO_2 of raising arterial PaO_2 from 100-150 to 200-250 torr during acute hyperventilation in 18 young patients (age, 28 ± 11 years; 12 males) with severe head injuries (Glasgow Coma Scale score, 5-8). All patients were normothermic and normotensive, with a hemoglobin level between 10 and 14 g/dL.

In addition to arterial catheters, jugular bulb venous catheters were placed and their location confirmed radiographically. Samples for saturation and PO_2 were obtained at baseline (PaO_2 = 100-150 torr, $PaCO_2$ = 30 torr), after 30 minutes of hyperventilation to a $PaCO_2$ of 25 torr, and again after return to baseline. The sequence was repeated after the FiO_2 was adjusted to produce a PaO_2 of 200-250 torr. Arterial-(jugular) venous oxygen content difference ($AVDO_2$) was calculated in each experimental condition and compared.

SjO_2 fell from 66% to 56% when $PaCO_2$ was reduced from 30 to 25 torr during normoxia. During hyperoxia, initial SjO_2 was 77% and fell to 64% with hyperventilation. At normoxia, when $PaCO_2$ was reduced from 30 to 25 torr, $AVDO_2$ rose from 5.3 to 7 volume percent. When PaO_2 was elevated to more than 200 torr, $AVDO_2$ was reduced from control to 4.2 volume percent; with hyperventilation to a $PaCO_2$ of 25 torr, it rose to 5.9 volume percent. Thus, increasing the PaO_2 to more than 200 torr returned the SjO_2 and $AVDO_2$ to baseline values, implying improved global oxygen uptake in the brain during hyperventilation in patients with severe head inury.

COMMENT BY CHARLES G. DURBIN, Jr, MD, FCCM

The importance of this study, which was performed in India, is its use of patients to study relevant clinical interventions. The data and conclusions are provocative. However, using moderate hyperventilation in head injury—the baseline condition in this study—has generally been abandoned due to studies demonstrating a worse outcome in less severely injured patients. Acute hyperventilation for abrupt increases in intracranial pressure remains an accepted, although unproven, therapeutic intervention. In this study, ICP was not monitored.

Several additional issues about this study need mentioning. The effects of hyperventilation on hemoglobin saturation and binding of oxygen may affect the results. Alkalosis increases the affinity of hemoglobin for oxygen, making it less available to tissues. This means that if the same amount of O_2 is taken up, the venous saturation will be lower with hyperventilation since less dissolved O_2 (leading to a lower venous PO_2) will be available to meet organ demands. This means that the fall in SjO_2 and rise in $AVDO_2$ could be related to shifts in hemoglobin affinity for oxygen, not just to changes in cerebral blood flow. The equation Thiagarajan et al used to calculate oxygen content employed the same constant for oxygen binding in calculating venous and arterial values. This does not negate the finding that increasing arterial saturation increased jugular venous saturation during hyperventilation, but it does bring into question the importance of the findings.

Another issue is the implication that cerebral ischemia occurred with hyperventilation and that increasing the SjO_2 improved ischemia. No evidence was presented that suggested inadequate oxygen uptake in any of the experimental conditions. Tissue oxygen demands should have been met by the increased $AVDO_2$ observed. Jugular venous lactate or creatine kinase brain fraction (CK-BB) would have been an interesting correlate to evaluate whether severe ischemia was occurring. Direct or indirect measurements of cerebral blood flow would have improved the interpretation of the observations in this study.

These criticisms aside, this study may have important implications to the everyday care of the head-injured patient. Increasing PaO_2 to greater than 200 torr during acute hyperventilation seems to have a salient effect on cerebral oxygen kinetics. Based on this preliminary study, increasing the inspired oxygen concentration during episodes of acute hyperventilation in head-injured patients is reasonable. ❖

Acute hyperventilation in patients with moderate head injury:

a. is associated with markedly improved survival.
b. causes cerebral acidosis.
c. causes a fall in SjO_2.
d. usually increases ICP.
e. has no effect on $AVDO_2$.

Do Low Tidal Volumes Prevent Lung Injury in ARDS?

ABSTRACT & COMMENTARY

Synopsis: *This multicenter randomized study of mechanically ventilated patients with ARDS found that a ventilator strategy that reduces tidal volumes to less than 10 mL/kg and limits end-inspiratory (plateau) pressure to 25 cm H_2O does not improve morbidity or mortality compared to current conventional ventilator*

management strategies.

Source: Brochard L, et al. *Am J Respir Crit Care Med* 1998;158:1831-1838.

Brochard and colleagues recruited patients with acute respiratory distress syndrome (ARDS) who had only one organ system involved (single organ failure) and who required mechanical ventilation. Brochard et al randomized the patients either to a low tidal volume (< 10 mL/kg) and low plateau pressure (< 25 cm H_2O) ventilator strategy or to a standard management strategy with tidal volume of more than 10 mL/kg (not to exceed 15 mL/kg) and a plateau pressure less than 35 cm H_2O. A "PEEP trial" was used to establish the optimal PEEP that improved oxygenation (as measured by PaO_2/FiO_2) without reducing cardiac output; this was designed to standardize PEEP in both groups. After 116 patients had been enrolled, the study was terminated after an interim analysis performed on the first 100 patients made it clear that enrolling more patients would not show the anticipated change in mortality (from 50 to 30%).

Brochard et al were successful in their efforts to randomize individuals to different management strategies. The ranges of tidal volumes and plateau pressures (from 1-14 days) for the low tidal volume group were 7.1-7.6 mL/kg and 25.7-24.5 cm of water, respectively. The ranges of tidal volumes and plateau pressures for the standard management group were significantly higher (10.3-9.9 mL/kg and 31.7-33.6 cm of water, respectively). There were no significant differences between management strategies in PEEP levels, PaO_2, FiO_2, incidence of barotrauma, or total mortality at 60 days. $PaCO_2$ was significantly higher in the low tidal volume group as compared to the standard tidal volume group (49.5-53.9 mmHg vs 41.3-44.7 mmHg) and there was a trend toward increasing use of paralytic agents in the low tidal volume group (P = 0.12).

COMMENT BY MARK T. GLADWIN, MD

Convincing animal data have suggested that limiting maximal transalveolar pressure to less than 30-35 cm H_2O would reduce the risk of ventilator-associated lung injury and overt barotrauma. Limiting tidal volume and end-inspiratory (plateau) pressure reduces transalveolar pressure and has been demonstrated to improve outcomes in small randomized and nonrandomized trials. This current multicenter randomized trial now complements two other recent studies of limited pressure and tidal volume ventilation in patients with ARDS (Amato MBP, et al. *N Engl J Med* 1998;338:347-354; Stewart TE, et al. *N Engl J Med* 1998;338:355-361).

With the exception of the study by Amato et al, all studies of low tidal volume ventilation for ARDS reported to date have failed to demonstrate an improvement in mortality or a reduction in barotrauma by limiting tidal volume to less than 8 mL/kg or PPLAT to less than 25-30 cm H_2O. In all these studies, the tidal volumes in the control group ranged from 10-12 mL/kg and the PPLAT to less than 35 cm H_2O. In effect, the control groups were maintained with low tidal volumes and PPLAT as compared to the historical use of tidal volumes of 15 mL/kg. It appears that maintenance of a PPLAT less than 35 cm H_2O is protective, as the rates of pneumothorax were relatively low, at approximately 13%, and the mortality rates ranged from 30-50%, depending on the severity of organ disease. It is also apparent that further reductions in tidal volume and PPLAT confer no added protection. An ongoing multicenter randomized trial of low vs high tidal volume in the United States has recruited more than 800 patients and hopefully will soon be able to answer this question definitively (personal communication: Gordon D. Bernard, MD).

To clarify association of tidal volume and barotrauma in mechanically ventilated patients with ARDS, the multinational trial of aerosolized synthetic surfactant in patients with ARDS was retrospectively evaluated by Weg and colleagues (Weg J, et al. *N Engl J Med* 1998;338:342-347). Weg et al reported a 6.9% incidence of pneumothorax in 725 patients and found no association between the presence of air leaks or pneumothorax and any tidal volume or pressure examined. The average tidal volume was 11.6 mL/kg and mean airway pressure was 24 cm H_2O. Unfortunately, they did not have PPLAT measurements to evaluate. This study suggests that pneumothorax is relatively uncommon in patients with ARDS undergoing conventional mechanical ventilation and may be related to the severity of the lung injury rather than high tidal volume ventilation. However, the historically used high tidal volumes of 15 mL/kg were not evaluated.

The only study to demonstrate an improved mortality with low tidal volume, low plateau pressure ventilation was conducted in Brazil (Amato MBP, et al. *N Engl J Med* 1998;338:347-354). This study used a number of ventilator manipulations: 1) limiting the inspiratory driving pressure to less than 20 cm H_2O above the level of positive end-expiratory pressure (PEEP) by using low tidal volumes and pressure-control ventilation; 2) employing "lung recruiting maneuvers" after suctioning or at any time the endotracheal tube is disconnected from the ventilator (brief application of high pressure, 35-40 cm H_2O, for 40 seconds); 3) allowing $PaCO_2$ to

rise (permissive hypercapnea); and 4) using PEEP set at 2 cm H_2O above the lower inflection point on the pressure-volume curve (PFLEX). The mean PFLEX was approximately 15 cm H_2O in this study. Patients were randomized either to this strategy or to a conventional strategy consisting of use of the lowest possible PEEP, tidal volumes of 12 mL/kg, and maintenance of a normal $PaCO_2$. Using this strategy, Amato et al reported a 38% mortality in the protective-ventilation arm of the study and a 71% mortality in the conventional arm. Rates of barotrauma were 7% and 42%, respectively.

There are a number of concerning aspects of this study that require further examination. In particular, the mortality and rates of barotrauma in the control arm were extremely high. In fact, in the two other large randomized trials of low tidal volume vs. conventional tidal volume ventilation (Stewart et al; Brochard et al), the mortality and barotrauma rates in the control arms were much lower. In fact, the mortality in Amato et al's treatment group was the same as in the control groups of these other studies. Therefore, these results remain suspect and the role of high PEEP and recruiting maneuvers must be further studied.

We can safely make two conclusions. First, limiting plateau pressures to less than 35 cm H_2O and tidal volumes to 10-12 mL/kg results in low rates of barotrauma and expected mortality rates for ARDS. Second, further reductions in plateau pressure and tidal volume appear not to improve outcome. Strategies that increase PEEP above the lower inflection point of the pressure-volume curve deserve further study. ❖

The Brochard study showed that managing ARDS patients with tidal volume less than 10 mL/kg and plateau pressures less than 25 cm H_2O, as compared with conventional management:

a. reduced both 60-day mortality and barotrauma.
b. reduced barotrauma but had no effect on 60-day mortality.
c. reduced 60-day mortality but had no effect on barotrauma.
d. had no effect on either 60-day mortality or barotrauma.

Antibiotic-Impregnated Catheters Superior

ABSTRACT & COMMENTARY

Synopsis: *Central venous catheters (CVCs) impregnated with minocycline and rifampin were one-third as likely to become colonized and only one-twelfth as likely to be the source of a bloodstream infection as CVCs impregnated with chlorhexidine and silver sulfadiazine.*

Source: Darouiche RO, et al. *N Engl J Med* 1999; 340:1-8.

Prevention of nosocomial infection related to central venous access is an important clinical goal. Darouiche and colleagues prospectively compared two antimicrobial-impregnated central venous catheters (CVCs) in a group of 865 insertions at 12 university-affiliated teaching hospitals. Patients who were at high risk (ICU patients or those known to be immunocompromised) and expected to need central access for at least three days were randomly chosen to receive 7 F, triple-lumen CVCs impregnated with chlorhexidine silver sulfadiazine (CSS) or minocycline and rifampin (MR). Only catheters inserted with an initial venous stick were included in the study population; no patients using over-a-wire change were studied. In addition to the usual semiquantitative culture techniques applied to catheter segments on removal, sonication culture of the catheter was used to increase the yield of potentially colonizing organisms. Indications for catheter removal were when it was no longer needed, if mechanical problems occurred, or if catheter-related infection was suspected.

Randomization for patient demographics, duration of cannulation, disease process, and reason for removal was successful in the 738 catheter placements in 698 patients completing the study (85% of the total 865 CVCs initially entered). Only one of the 350 MR CVCs was associated with a bloodstream infection compared to 13 of the 370 CSS catheters ($P < 0.002$). Twenty-eight of the MR CVCs (7.9%) were colonized as compared to 87 of the CSS (22.8%); $P = 0.001$. No complications related to CVC impregnation, including patient hypersensitivity or antibiotic resistance, were noted in either group.

COMMENT BY CHARLES G. DURBIN, Jr., MD, FCCM

Both of the catheters used in this study have previously been shown to reduce the incidence of catheter-related infections and to about the same extent when compared to nontreated catheters. This is the first head-to-head trial of both types of catheter. Darouiche et al mention several facts about the devices they used: the MR catheters are impregnated inside and outside; the catheters used in this study had almost five times the amount of minocycline and 20 times the amount of rifampin per catheter as those used in earlier studies; and CSS catheters are only impregnated on the outer surface. The MR catheters are about $11 more than the CSS and about $50 more than a conventional catheter (using my estimate of $20 for a conventional CVC).

Other interesting factors reported in this study were that the femoral and jugular routes (together) had two-

to fivefold increases in catheter-related infection rates compared to subclavian placement; that men were more likely to experience catheter-related infection than women; that the rate of catheter-related infection was related to the duration of catheterization; and that patients in the ICU or on mechanical ventilation had higher catheter-related infection rates.

While the outcome differences are impressive, there are several concerns about these study data and their implications. The infection rate of the CSS catheters reported in this study is much higher than previously reported. The average reported bloodstream infection rate is only 1%, with a colonization rate of around 12% for CSS catheters in other studies. The rate of bloodstream infections of 3.4% and a colonization rate of 22% suggest a problem with diagnostic accuracy or catheter care. Darouiche et al suggest that sonication enhances the "yield" of organisms and may be part of the reason for the high rates. This procedure is not yet the accepted method of diagnosis and is not routinely available for clinical use. The data should have included what was found using the traditional rolled-catheter, colony-forming units method of identifying infection.

Another explanation of the results offered by Darouiche et al is that the MR catheters are coated inside as well as outside. If line infection originates hematogenously as well as from the skin, this may be important in decreasing infection. It also suggests that failure of aseptic line management may be occurring in this study. Line dressing techniques also contribute to catheter-related infections. The dressing technique is not described in this study. Occlusive dressings and use of neosporin ointment have the highest catheter-related infection rates; nonocclusive, chlorohexidine cream, the lowest. The type of line dressing should have been made clear in the paper.

These concerns aside, this is promising new information and any patient with a central venous catheter that is expected to remain in place for more than seven days may benefit from an antimicrobial catheter or placement technique. The true difference between MR and CSS catheters, catheter tunneling, and collagen plugs awaits additional testing. ❖

Catheters impregnated with minocyline and rifampin:

a. now contain less antibiotic than earlier generations.
b. exhibit a higher colonization rate than those impregnated with chlorhexidine and silver sulfadiazine.
c. are associated with a significant number of allergic reactions.
d. increase the resistance rate of environmental pathogens.
e. reduce the bloodstream infection rate compared to catheters impregnated with chlorhexidine-silver sufadiazine.

Reducing Complications in the ICU

ABSTRACT & COMMENTARY

Synopsis: *Grade A Evidence supports the increased risk for DVT and VTE in critically ill patients and, thus, the use of prophylactic measures against these complications in such patients.*

Source: Saint S, Matthay MA. *Am J Med* 1998; 105:515-523.

Saint and matthay comprehensively reviewed the recent medical literature on the epidemiology of three important complications associated with ICU care: venous thromboembolism, stress-related upper gastrointestinal bleeding, and vascular catheter-related infections. They sought to derive evidence-based recommendations from reported studies pertaining to these complications. Relevant publications were located via a MEDLINE search and cross-citation, focusing on reports published in the last 10 years; on meta-analyses; and on rigorously designed and carried out clinical trials. The levels of evidence provided by each reviewed study (e.g., Grade A = evidence based on results from at least one randomized control trial primarily in ICU patients, etc.) were recorded and used in developing Saint and Matthay's recommendations. A summary of their recommendations follows.

Venous Thromboembolism (VTE)

Patients in the ICU are at greater risk for developing VTE than are other patients. Those at increased risk for developing VTE in the ICU include those with age older than 40 years, prior eposodes of VTE; underlying malignancy; prolonged immobility or paralysis; major surgery; congestive heart failure; fractures (especially of hip, pelvis, or leg); and stroke. Patients with hypercoagulable states, such as protein C resistance or dysfibrinogenemia, are at especially increased risk. Several studies document the fact that relatively few of the patients who fall into these increased risk groups receive VTE prophylaxis while in the ICU.

Measures to prevent VTE are effective, although data come mainly from studies in surgical patients. Low-dose unfractionated heparin (e.g., 5000-7000 U subcutaneously every 8-12 hours) is effective in reducing the incidence of deep venous thrombosis (DVT) in a variety of patient groups. Low molecular weight heparin is also effective in preventing DVT in surgical and stroke patients, but few studies have been done in medical patients; it is considerably more expensive than unfrac-

tionated heparin. Intermittent pneumatic compression is also effective for several groups of surgical patients that have been studied, and is a reasonable alternative for patients who cannot receive anticoagulants.

Saint and Matthay conclude that Grade A evidence supports the increased risk for DVT and VTE in critically ill patients and, thus, the use of prophylactic measures against these complications in such patients. They conclude that either unfractionated or low molecular weight heparin can be used. The evidence that intermittent pneumatic compression may be substituted for either form of heparin is less compelling, especially in medical patients.

Stress-Related Upper Gastrointestinal Bleeding

Upper gastrointestinal (GI) bleeding is common in patients admitted to ICUs. Those at most risk are patients with respiratory failure requiring mechanical ventilation and those with coagulopathy (e.g., platelet count < 50,000/mL or prolonged prothrombin or partial thromboplastin time). Patients with extensive burns and those with multiple traumatic injuries may also be at increased risk.

From their study of available evidence, Saint and Matthay conclude that prophylaxes with H_2-receptor antagonists prevent clinically important upper GI bleeding but have not been shown to affect mortality. They recommend prophylaxes with H_2-receptor antagonists for patients with coagulopathy or on ventilators whose anticipated duration of ventilatory support will be less than four days. For patients whose anticipated duration of ventilatory support will be more than four days, they recommend sucralfate because of the potential for increased propensity to ventilator-associated pneumonia with the use of H_2-receptor antagonists in such patients. Saint and Matthay point out, however, that the strength of the evidence here is less than with the prevention of DVT and VTE.

Catheter-Related Vascular Infection

Risk factors for catheter-related vascular infections include longer duration of catheterization, catheter location (e.g., femoral or internal jugular vs subclavian sites), the use of transparent dressings (which may increase the risk), the absence of systemic antibiotic therapy, and the use of less stringent barrier precautions during placement. It is uncertain whether multilumen catheters increase the risk for catheter-related infections.

Chlorhexidine gluconate is the agent of choice for skin disinfection prior to catheter insertion. Central venous triple-lumen catheters impregnated with antibacterial agents are probably preferable to nonimpregnated catheters when the line will be in place for less than seven days and the patient remains at increased risk for infection despite rigorous adherence to appropriate infection control practices. Central venous lines, pulmonary arterial catheters, and arterial lines need not be changed routinely at any fixed interval so long as there is no evidence for local catheter-related infection, fever without a clear source, or catheter malfunction. Transparent dressings may increase the risk for local infection but provide other benefits that may justify their use. Saint and Matthay recommend that pulmonary artery catheters not be used unless the patient is likely to benefit from the availability of central hemodynamic data, although they state that the evidence here is not from properly designed randomized control trials.

COMMENT BY DAVID J. PIERSON, MD

This is a useful examination of a sometimes confusing body of literature on three important ICU-related complications. An accompanying article (Gould MK, et al. *Am J Med* 1998;105:551-553) points out that Saint and Matthay did not perform a formal meta-analysis or use the usual format of a systematic review, and that their paper is more a comprehensive narrative review of the subject under consideration. Nonetheless, it is helpful to clinicians to have the current literature summarized in a structured manner and to have recommendations presented along with summaries of the data on which they are based.

Venous thromboembolism, stress-related upper GI bleeding, and catheter-related infections are common, important complications with which everyone working in the ICU environment needs to be concerned. There is abundant evidence that patient care in many settings falls far short of the state of the art in this area. The recommendations of Saint and Matthay are reasonable, practical, and based on a rigorous examination of the available literature. Patient outcomes in the ICU would likely improve if these recommendations were more widely followed. ❖

Grade A evidence for an ICU treatment or practice means that it is based on:

a. results from several prospective series published in leading journals.
b. results from at least one randomized control trial primarily in ICU patients.
c. the experience and judgment of an internationally recognized expert.
d. a hospital policy that is appropriately referenced to the literature.
e. a published study demonstrating P less than 0.05 vs. other treatments or practices.

Intrinsic PEEP Predicts Lung Reduction Success

ABSTRACT & COMMENTARY

Synopsis: *Patients with preoperative intrinisic PEEP ($PEEP_i$) less than 5 cm H_2O failed to improve in dyspnea score or forced expiratory volume in one second (FEV_1) when evaluated three months following lung volume reduction surgery (LVRS). Patients with $PEEP_i$ 5 cm H_2O or more were likely to be improved following LVRS.*

Source: Tschernko EM, et al. *Anesth Analg* 1999 (Jan);88:28-33.

Lung volume reduction surgery (lvrs) for severe emphysema awaits confirmation of clinical efficacy. It is known that some patients have dramatic, subjective, and measurable objective improvements following this radical surgical approach while others fail to obtain benefit. Preoperative predictors identifying appropriate candidates are being evaluated. Tschernko and associates studied 32 patients undergoing LVRS. Preoperatively, they measured total resistive work of breathing (WOB), mean airway resistance (Raw), and dynamic intrinsic PEEP ($PEEP_i$), in addition to the usual monitors of the severity of chronic lung disease (FEV_1, FVC, arterial blood gases, pulmonary artery pressures, chest CT, and ventilation/perfusion scans) in 32 patients. Using a video-endoscopic approach, 20-30% of each lung was removed, concentrating on the most abnormal lobes.

Two patients were excluded: one could not be weaned postoperatively and underwent lung transplantation, and another developed the acute respiratory distress syndrome (ARDS) and died of multiple organ failure. The 30 remaining patients were extubated within 24 hours and served as the test group. The average age was 56 years, and there were 18 men and 12 women. The group's average FEV_1 was 0.75 L, or 25% of predicted. The group's PaO_2 ranged from 54-90 mmHg, $PaCO_2$ from 34-77 mmHg, and two-thirds of the patients were on chronic oxygen therapy. The following surgery improvements in most parameters were noted.

Table

Surgery Improvements

Parameter	Preoperative	Postoperative
FEV_1	0.75 L	1.18 L
WOB	1.65 J/L	0.93 J/L
Raw	17.3 cm H_2O/L/sec	9.7 cm H_2O/L/sec
$PEEP_i$	6.3 cm H_2O	1.9 cm H_2O

Five patients failed to improve at all following surgery; the others improved objectively by at least 10% in FEV_1. Using a variety of cut points for each of the parameters, $PEEP_i$ greater than or equal to 5 cm H_2O was found to be the best predictor of improvement in FEV_1 and dyspnea score postoperatively, demonstrating a sensitivity of 0.93 and a specificity of 0.88. This predicted at least a 40% increase in FEV_1 postoperatively.

COMMENT BY CHARLES G. DURBIN, Jr., MD, FCCM

This study offers a cut point for clinical use in deciding who will benefit from LVRS. It also identifies those who may not. Tschernko et al defined a good result as an increase in FEV_1 of at least 40%, the group average being 0.75 L preoperatively. This is a high expectation and, if it holds up in other patients, should result in unquestioned benefit. It is interesting to note that none of the other tested variables performed as well in predicting success as did $PEEP_i$.

Using the suggestions of Tschernko et al, measurements must be made carefully during quiet breathing with an esophageal pressure balloon. Simple, reliable equipment was used (Bicore 100), and well-experienced clinicians must evaluate the obtained data. The other variables obtained also correlated with success but were not as good as $PEEP_i$ for separating success from failure.

This study only reports early, three-month success. Whether continued improvement persists for longer remains to be evaluated. It is too early to suggest that the $PEEP_i$ be used to deny patients access to LVRS, but advisable that any study of the outcome of these patients include this variable in the evaluation data set. ❖

Lung volume reduction surgery performed in patients with COPD results in:

a. higher PaO_2 in most patients.
b. mortality of less than 0.5%.
c. improved symptoms in most patients.
d. the need for lung transplant in 20% of patients.
e. higher intrinsic PEEP in the majority of patients.

In Future Issues:

New Technique for Excluding Esophageal Intubation

Invasive Pulmonary Aspergillosis in the ICU