NEW DEVELOPMENTS IN THE ANESTHETIC MANAGEMENT OF TRAUMA

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Interest in and knowledge of the anesthetic management of trauma is growing rapidly and has led to special symposia such as this one in which Dr. T. Fugita, Professor of Anesthesiology in Gunma, Japan, lectured. The interest has led to the spread of a new organization, the World Society of Disaster and Critical Care Medicine, with chapters in many countries of the world. The Japan Society of Clinical Anesthesia is properly interested in anesthesia for trauma and I am pleased to participate in your annual meeting in Miyazaki. New developments have occurred in airway control, analgesia, prevention of aspiration pneumonitis, management of open-eye injuries, and fluid resuscitation.

AIRWAY CONTROL

The traumatized patient requires rapid initial assessment of the severity and extent of injuries when he is first seen. In severe cases the assessment is conducted while treatment is initiated. The first priority is given to airway control and gas exchange, followed by evaluation of blood volume and peripheral perfusion and by evaluation of CNS function. Proper early airway management would save many lives. No magic formula or logical algorithm can provide a decision path which will be correct in every case. We must start with simpler things. Dramatic relief of obstruction can
result from head tilt and jaw lift in both conscious and unconscious patients. Removal of foreign material such as blood, dentures, food, vomitus, fragments of teeth and bones should precede the insertion of an oral airway. Removal is accomplished manually or with suction.

At this point the teachings of emergency medicine and anesthesiology diverge. The anesthesiologist would take up the laryngoscope, visualize the larynx, and pass an orotracheal tube. Emergency medicine on the other hand teaches that the next step should be a blind nasotracheal tube because it is the safest, most expeditious method, it is more comfortable for the patient, it cannot be occluded by clenched jaws, and it can be done with less head manipulation. Nasotracheal intubation is contraindicated in patients with midface fractures, basilar skull fractures, hemostatic disorders, upper airway foreign bodies, or upper airway tumors.

Prepare the nose with oxymetazoline 0.1% or with a mixture of phenylparine 1% and lidocaine 2%. Place the head in the "sniffing position." Select a 7 mm ID tube for men and a 6 mm ID for women. Elevate the tip of the nose and insert the tube parallel to the hard palate. Advance the tube with gradually increasing forward pressure (in contrast to an in-and-out stabbing action.) The tube will flip or release as it turns off of the posterior pharyngeal wall into the oropharynx. Rotate the tube until breath sounds are maximal. A whistle (BAAM, Great Plains Ballistic Co., Lubbock, Texas) helps in identification of the pathway of maximal airflow. With airflow as a guide, advance the tube quickly during inspiration. If breath sounds cease, the tube has entered the pyriform sinus. Retract and try again. If breath sounds are maximal and accompanied by coughing efforts the trachea has been entered; begin respiratory therapy and secure the tube.

Serious complications are rare but perforation of the pharyngeal
mucosa, submucosal tunneling, mediastinitis, laryngeal injury, broken turbinates, and broken septum have all been reported. In my opinion (NOT scientific) transtracheal block enhances the success of the procedure without increasing the risk. Transtracheal block and preparation of the nose with local anesthetics make the whole procedure more acceptable to the conscious patient. If needed, some IV sedation can be used. I prefer midazolam IV in one mg increments waiting 2 minutes between doses until the patient develops nystagmus or slurred speech. This usually requires 2-3 mg. One should stop before the patient loses consciousness to prevent respiratory depression or arrest.

In the event that nasotracheal intubation is unsuccessful the anesthesiologist would proceed with direct laryngoscopy. The teachings of emergency medicine advise going on to cricothyrotomy. The procedure requires a scalpel with No. 11 blade, a hemostat, a tracheal hook, and standard tracheotomy tube.

Extend the head, prepare the skin with 10% providone, and infiltrate the skin with lidocaine 1%. Palpate the cricothyroid membrane, grasp the thyroid cartilage with the thumb and forefinger, incise the skin horizontally over the cricothyroid membrane, make a horizontal incision in the membrane, hold the wound open with the tracheal hook, and insert the tracheostomy tube. Secure the tube and begin respiratory therapy.

Endotracheal intubation is indicated early in any patient with clinical respiratory distress, chest wall instability, and paradoxical movement, thermal injury of the airway, and unconsciousness whether traumatic, metabolic, or toxic. Patients with severe hypotension which does not respond readily to intravenous fluids should be intubated.

Fractures of the cervical spine coincide with head injuries in 1-5% of
the cases. Radiographic clearance of the cervical spine should be obtained prior to any intubation technique which requires head manipulation. When time does not permit this the physician should choose between blind nasal intubation, cricothyroidotomy, or carefully conducted direct laryngoscopy during which the head is held by an assistant (usually the neurosurgeon) who watches for inappropriate head motion.

In urgent situations intubation with a fiberoptic laryngoscope or bronchoscope is not appropriate. The value of digitally guided intubation, light wand intubation, or intubation with the new Bullard laryngoscope (Circon ACMI) is yet to be proven.

**ANALGESIA**

Knowledge of analgesia is a basic skill required in the practice of emergency medicine. The emergency physician should be familiar with the indications and contraindications of oral, intramuscular, intravenous, and inhalational analgesia. Selection of drugs depends on the needs of the patient, available equipment, and physician's preference.

A self-administered, fixed 50% mixture of nitrous oxide and oxygen which is prescribed by a physician has been used successfully by ambulance services in the United Kingdom, United States, Canada, and Nigeria in a wide variety of painful conditions including obstetric, medical, surgical, and traumatic pain. It is readily absorbed and quickly excreted, it provides good relief of pain, and it is safer than other agents in properly selected patients. It must always be self-administered by the patient. It is contraindicated in patients who cannot understand and follow instructions; who are semiconscious or unconscious; who have dyspnea, cyanosis, or suspicion of pneumothorax; who have decompression sickness ("bends") or air embolus; who have severe obstructive lung disease or who have abdominal pain with distension or suspicion of bowel obstruction.
concentration of nitrous oxide in the patients' compartment of an ambulance or in a poorly ventilated emergency room can exceed the recommended minimum unless the air conditioner fan is activated or a scavenger system is used.  

PREVENTION OF ASPIRATION PNEUMONITIS

Aspiration pneumonitis continues to be responsible for 30% of the deaths associated with anesthesia and is a significant cause of the adult respiratory distress syndrome (ARDS). In my opinion prevention of aspiration pneumonitis deserves our most careful consideration. The measures required to prevent aspiration pneumonitis can be compared to a chain which is only as strong as its weakest link. The first measure is to recognize the patient at risk. Since gastric emptying ceases at the time of a significant injury, the interval from the last meal to the accident is more important in predicting a full stomach than the traditional interval from the meal to the induction of anesthesia. Other patients who are at risk are parturients in labor, obese patients, outpatients, patients with scleroderma or hiatal hernia, diabetics with gastric retention resulting from autonomic neuropathy, and patients with impaired consciousness.

The second measure is to avoid general anesthesia or heavy sedation during regional analgesia. If general anesthesia must be used then we must reduce volume of gastric contents, modify the pH of gastric contents, and prevent soilage of the airway by regurgitated gastric contents, which are the last three measures or links in the chain.

The volume of gastric contents can be reduced with a nasogastric sump tube which should be inserted prior to induction of anesthesia if the patient has a distended abdomen but should be inserted intraoperatively in all patients after endotracheal intubation. Contraindications to a nasogastric tube include open-eye injuries, basilar skull fractures, and
penetrating wounds of the neck. Metaclopramide tightens the cardia, relaxes the phlorus, and empties the stomach into the duodenum. It is effective in traumatized patients. It is also an effective antiemetic in the recovery room. The value of metaclopramide in traumatized patients is presently being tested in several studies.

The potential of gastric contents to produce severe aspiration pneumonitis is greater if the pH is less than 2.5. Anticholinergics such as hyoscine or glycopyrrolate are ineffective. The $H_2$ blockers (cimetidine and ranitidine) will reduce the volume and acidity of gastric contents for four hours following administration. That's good for the elective patient but of no value to the traumatized patient because the drug has no effect on existing gastric contents. The pH of existing gastric contents must be altered with antacids.

At one time we could choose from a wide variety of commercially available antacids; Milk of Magnesia, Maalox, Riopam, or Kolanta-gel. Pulmonary toxicity results from intratracheal instillation of these particulate or colloidal antacids. As a result we have experienced a nationwide shift to clear antacids which have less pulmonary toxicity.

The clear antacids available to us are sodium citrate 0.3 molar, Bicitra, Alka Seltzer Gold, or sodium bicarbonate 8.4%. These mix better with gastric contents, neutralize more rapidly but are shorter acting, and must be given just prior to induction.

Here are the results of a recent project completed at Parkland Hospital. On the vertical axis we recorded the gastric pH of 97 elective patients who have received Bicitra as a preinduction antacid. After intubation a sump tube was passed into the stomach, a sample removed, and the pH measured. On the horizontal axis we plotted the time interval in
minutes from the dose of Bicitra to the removal of the sample. In the interval from 10 to 30 minutes none of six patients had pH less than 2.5. In the interval from 30-60 minutes three of 28 had pH less than 2.5 and in the interval from 60 to 120 minutes 30 of 47 patients had pH less than 2.5.

To me the conclusion is as clear as the antacid. Bicitra must be given 10-60 minutes before induction of anesthesia. If the interval is longer than 60 minutes the dose should be repeated.

The most widely accepted method to protect the airway from soilage by gastric contents is endotracheal intubation. Whether one selects an awake or rapid sequence intubation depends on obesity, anatomy, pathology, or presence of injuries.

If you have chosen a rapid sequence induction, effective cricoesophageal compression (CEC) is mandatory. Press on the cricoid, not the thyroid. Do not release until airway is secure. Good CEC will withstand 100 cm of water intragastric pressure before regurgitation into the pharynx will occur. CEC should be done with two hands. The assistant's right hand is placed behind the neck lifting up and his left hand is pressing on the cricoic cartilage. The lifting action in the back of the neck places the head automatically in an improved sniffing position. The two-handed technique can be applied in supine, lateral, or any other position.

OPEN-EYE INJURIES

Anesthesiologists and ophthalmologists have been concerned about the use of succinylcholine for rapid sequence induction in patients with open-eye injuries. Succinylcholine has been demonstrated to increase intraocular pressure which might result in loss of ocular contents and blindness in these patients. Anesthesiologists have tried various ways to use nondepolarizing muscle relaxants for rapid sequence inductions. We have used large doses before the thiopental (vecuronium 0.2 mg/kg IV,
pancuronium 0.15 mg/kg) and we have tried split doses or the "priming principle" (i.e., give 10% of the intubating dose, wait 5 minutes, give the rest of the intubating dose after the thiopental, and attempt intubation in 90 seconds). For a variety of reasons these substitutions for succinylcholine have been less effective and in some cases even dangerous.9,10 I have returned to the use of succinylcholine following an anti-fasciculatory dose of curare for open-eye injuries.11

FLUID RESUSCITATION

Reasonable physicians agree that when the patient sustains a significant trauma (whether social, industrial, vehicular, or surgical), the hypovolemia which results should be treated with appropriate volumes of some fluid. Disagreement exists on the type of fluid to be administered. Proponents of the use of colloids contend that since the deficit occurs initially and primarily in the vascular space, a colloidal solution should be given which remains in the vascular space.12 Traumatic injuries, burns, infections, and many other surgical conditions lead to a transfer of healthy or functional extracellular fluid into a nonfunctional space called acute sequestered edema or the "third space," thereby creating deficits in many spaces in addition to the vascular space. The fluid which has been sequestered in edema is nonfunctional in that it does not perform the physiologic duties of healthy interstitial fluid. A deficit of intracellular fluid, functional interstitial fluid, and plasma volume results from this sequestration of fluid into a nonfunctional space. This edema remains for a period of two to four days, then is gradually mobilized from the sequestered space where it played some poorly understood role in the healing process. This fluid exits the body as urine during the phase of resolution.

The status of the extracellular fluid in a patient in hemorrhagic shock is more complex and less well understood. The functional extracellular
fluid deficit averages four liters for the 70 kg adult in hypovolemic shock. When blood is lost, some interstitial fluid moves into the blood vessels to restore plasma volume and some moves into the cell, perhaps as a result of altered permeability of the cellular membrane. The new edema space associated with hemorrhagic shock appears to be intracellular. Whole blood alone corrects the deficit of blood volume, but leaves the deficit of functional extracellular fluid uncorrected. Unstable vital signs and poor urine output often continue. Restoration of both spaces (plasma volume and interstitial fluid) is possible with the combined use of a colloid and a crystalloid solution.

Evidence that balanced salt solution is preferable to colloid during fluid resuscitation in a variety of clinical situations is growing. During aortic reconstructive surgical procedures, two recent studies have demonstrated that balanced salt solution is as effective as colloid in maintaining cardiac output, pulmonary artery occluded pressure (PAOP, also called wedge pressure), and urinary output. The amount of balanced salt solution necessary to maintain these values was twice the quantity of colloid necessary. The colloid group had significantly higher cardiac output during the early postoperative period of the operative day, but no difference was noted after this period. However, the urine output in the colloid group had fallen to 50% of the balanced salt solution group on both the first and second postoperative days. Since twice as much fluid intraoperatively was required in the group receiving the balanced salt solution, those patients had more fluid to mobilize during the resolution phase. This diuresis may provide a degree of renal protection during the postoperative period in these patients. In a study of hemorrhagic shock, no difference in base deficit could be demonstrated between balanced salt solution or colloid resuscitation.

Some concern has been expressed in the past about the possibility of
inducing pulmonary edema by reducing the colloid osmotic pressure (COP, also called oncotic pressure), and the gradient between the COP and the PAOP (COP-PAOP) with the use of balanced salt solutions for resuscitation.

During aortic reconstructive surgery, the use of colloid results in no change in COP, COP-PAOP, or extravascular lung water; whereas, the use of balanced salt solution induces significant reductions in both COP and COP-PAOP for several days postoperatively but extravascular lung water did not increase. These observations tend to confirm that increases in hydrostatic forces (PAOP) are much more important in production of pulmonary edema than reductions of oncotic forces (COP). Patients who have preoperative evidence of compromised left ventricular function could not tolerate even small increases in PAOP caused by the infusion of colloid. A decrease in extravascular lung water was demonstrated in both the balanced salt solution and colloid groups for 36 hours after severe thermal injury.17 By six days after injury the extravascular lung water was significantly above the baseline measurement in the colloid group, while the balanced salt solution group had returned to the baseline value.

Roentgenographic evidence of early pulmonary edema occurred in five patients in the colloid-managed group and one patient in the group managed with balanced salt solution. This study implies that colloids can escape damaged capillary membranes, increasing the oncotic pressure in the interstitium. Sepsis also plays an important role. Another study shows that in the first day after thermal injury in patients managed with balanced salt solution the extravascular lung water fell in spite of a 50% drop in COP.18 In three patients who died of sepsis, the extravascular lung water increased significantly one to two days after the onset of infection.

The reduced COP which results from dilution of serum proteins during resuscitation with balanced salt solutions does not alter prognosis. In a prospective study, 114 patients in a surgical intensive care unit were given albumin whenever their COP fell below 29 dm H₂O. The clinical outcome
was the same in both groups but the postoperative albumin consumption and cost of treatment were lower in the second group. A reasonable conclusion is that pulmonary failure following trauma and hemorrhage has a complex etiology and is not related to the volume or type of solution used for resuscitation.

REFERENCES


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