Deepening knowledge of perioperative ventilatory challenges in high-risk patient groups and technical performance needs in an anesthesia ventilator

Obese and morbidly-obese patients – addressing the challenges of perioperative ventilation

Dr Robert H. Pinsker, Medical Director of Anesthesiology at El Camino Hospital and Dr Jeremy Collins, Chief Assistant Professor of Anesthesia at Stanford University Hospital, both in Silicon Valley’s Palo Alto, California. Dr Jan Paul J. Mulier, MD, PhD. Sint Jan Hospital, Brugge, Belgium

Peri-operative ventilation – What criteria are important for the widest range of patients?

Dr Javier Garcia Fernandez, The University Hospital of La Paz, Madrid, Spain

The need for high ventilatory performance in anesthesia – perspectives from two clinicians in anesthesiology

Professor Capdevila, The University Hospital (CHU) of Montpellier, France and Professor Lönnqvist, pediatric anesthesiologist at Astrid Lindgren Children’s Hospital at Karolinska University Hospital, Stockholm, Sweden

Thoracic surgical patients – Addressing the peri-operative ventilatory challenges in this high-risk group

Sahlgrenska University Hospital, Gothenburg, Sweden
In the past 30 years, mechanical ventilation in the Intensive Care Unit has benefited from extensive research in the field as well as some very specific lung protective ventilation strategies which have now been implemented into daily practice. In contrast, there has been less focus on research in peri-operative ventilation; but this too, is changing, parallel to important changes in patient demographics. The increased focus on research in anesthesia thereby improves the quality of peri-operative ventilation. CCN has taken a closer look at how clinicians experience these changes and what challenges they face.

Deepening knowledge of peri-operative ventilatory challenges in high-risk patient groups and technical performance needs in an anesthesia ventilator
Many studies have shown that the most frequently reported causes of postoperative morbidity and mortality are pulmonary complications. This is true especially among patients who have undergone abdominal and thoracic procedures and any patient presenting high co-morbidity. The increasing average age of elderly patients brings an additional twist to this situation; their pre-operative pulmonary status may be complicated by diminished compliance, COPD, pneumonia, or other physiological changes associated with ageing. Another factor which may have a negative impact on peri-operative pulmonary function is obesity, which is globally on the rise. Pulmonary complications may even occur unexpectedly in standard procedures in patients presenting certain complicating factors.

With the development of medical and surgical advances, a greater number of patients presenting for both emergency and elective surgery survive today; however, this in turn has changed the needs anesthesiologists have in terms of the performance they expect from anesthesia systems. In the last year and a half, Critical Care News has interviewed several anesthesiologists with specialities in pediatrics, obesity, trauma and general surgery from both Europe and the United States, with the aim of understanding the challenges they face daily. Parallel to this, MAQUET Critical Care launched its new anesthesia system, FLOW-i, in 11 European countries. In preparation for delivery, User Validation sessions have been held in Germany, Sweden, Italy and Belgium. Up to date, over 300 patients have undergone general anesthesia with FLOW-i. And the results overall have been very satisfactory.

In this first Anesthesia edition, Critical Care News relates the interview done in a Thoracic surgical unit in a university hospital in the southwest of Sweden, as well as first impressions of FLOW-i in clinical settings.

Critical Care News shall be busy continuing its interviews of other high-risk patient groups and you may look forward to reading about them in the next number of the Anesthesia edition in June 2011.
Thoracic surgical patients
– Addressing the peri-operative ventilatory challenges in this high-risk group

Thoracic surgical patients are recognized as belonging to a high-risk patient group in anesthesia. In March, CCN had the privilege of visiting Sahlgrenska University Hospital in Gothenburg, Sweden. Sahlgrenska is a university hospital and has a cooperation program with the Sahlgrenska Academy of the Gothenburg University’s Health Sciences department. They together account for more than 300 research projects. The hospital’s lung transplantation program began in 1990 with the first heart-lung transplantation. Since 1990 when the program began, more than 300 procedures have taken place. Sahlgrenska and Lund hospitals are the only centers in Sweden for heart and lung transplantations. Approximately 30 lung transplant cases are done each year, 10 of which are in need of a heart-lung machine.

The purpose of our visit was to speak to a few clinicians working with this speciality and to look in on a couple of ongoing lung surgery procedures.

We met with Jan-Olof Berglund, nurse anesthetist responsible for medical devices in the Department of Thoracic surgery to learn about the demands clinicians have on anesthesia machines in this field. We also spoke to Dr Anne Westerlund of the Department of Anesthesiology for the Cardio-thoracic Surgical Center, to learn about the anesthetic considerations of lung transplantation.
Most of the patients in need of lung transplants are patients with severe pulmonary hypertension, COPD, cystic fibrosis, silicosis, bronchiolitis obliterans and retransplantation after organ rejection, to name a few.

How old are most of the patients undergoing a lung transplantation?

Jan-Olof Berglund, nurse anesthetist: Many patients are between 50 and 60 years of age; we do have the occasional child or teenager, but this is quite rare.

Could you tell us about your experience of this procedure? Are all procedures quite alike?

I personally think that lung transplantation has become very routine-like. We follow a certain pre-operative routine, the same as the one for heart-lung procedures: the patient takes a shower, is scrubbed and shaved. The induction phase is done according to a specific protocol, which Dr Westerlind will describe later; the patient is positioned in lateral decubitus. The actual procedure can take from 3-4 hours, to sometimes much longer, due to certain complicated surgical aspects: it takes time to see how to put the different anatomical parts together.

With the anesthesia systems you are using, do you find that they can have certain shortcomings, or do they fulfill your needs for these procedures?

When the patient is in the lateral position, lying on the remaining lung which often is also sick, although healthier than the one being replaced, there are a few challenges; one obtains very high airway pressures, high resistances. This definitely challenges the machine that we have, which can only go up to 80 cmH₂O, as this gives a pressure inside the patient of 50-60 cmH₂O. This is not always sufficient for our patients in some extreme situations. Every now and then we have had to bring in an ICU ventilator.

You had the chance to see and hear about MAQUET’s FLOW-i anesthesia system in Uppsala. What do you think about its potential?

The technical capacity is very similar to an ICU ventilator, it is as powerful. And I like the design, it seems very easy to use.

We have learned what the chronic indications are for lung transplantation. Are there any emergency indications?

Dr Anne Westerlind, MD, PhD: No, there are no emergency indications for lung transplantation.

Do you have any specific demands from a ventilator during a lung transplantation procedure?

In the past, we used to do sequential lung transplantation with a heart-lung machine. Nowadays the transplantation often is done without a heart-lung machine and therefore we have high expectations of a ventilator as the “remaining” lung is also often very ill. Sometimes we have brought the SERVO 900 in to the operating room for this procedure.

Patients suffering from chronic pulmonary disease necessitating lung transplantation must logically have an advanced respiratory insufficiency. How do you prepare these patients in the pre-operative period?

We require that these patients quit smoking if they are smokers; we also teach them CPAP with which they must train up their respiratory function, learn how to cough effectively without damaging the anastomosis. These patients must also learn how to inhale: they are given Nitric oxide or Prostacyclin via a nebulizer for the purpose of pulmonary vasodilatation. In terms of the most important medication, we start these patients on immune-suppressive anti-rejection drugs.

Are there any contra-indications to lung transplantation or any age limit?

We would normally not accept a patient weighing 300 kilos, they should otherwise be quite healthy to be able to go through such a demanding procedure, and these patients do have complicating factors due to their obesity. There is no age limit either, it is co-morbidity which indicates whether or not this patient is a good candidate; therefore in practice, an 80-year old patient will not pull through this procedure, so that would be, in practice, a given age limit.

Could you please describe the settings you use on the anesthesia machine during lung transplantation?

With lung surgery, we set a fresh gas flow of 2 to 3 liters/minute, but it all depends on how much leakage there is; we often try to go even lower. It is important for us to be able to perform rapid changes so as to better be able to regulate the depth of anesthesia. Our general lung-surgery patients can have leaks of up to 5-6 liters. In the case of lung transplantation, there is a
situation of forced open pneumothorax and in this case, we do not use inhalation anesthesia as the agents would then contaminate the operating room air. We intubate the patient with a double-lumen endotracheal tube; this has the advantage of rapid inflation and deflation of either lung. The oxygen is set at no more than 60% in order to prevent atelectasis. Induction is produced routinely with either Pentothal or Propofol, Fentanyl and a muscle relaxant; often fiber-optic bronchoscopy is used for controlling the appropriate position of the tube.

We proceed systematically to lung recruitment manually with the APL valve at 50-60 cmH₂O during short intervals. We do not allow our patients to have high pressures; the PEEP level is set between 5 and 10 cmH₂O, even with our heart patients. Patients may need a lengthened Insp/Exp ratio as they have such low compliance due to their stiff lungs. Higher tidal volumes combined with lesser respiratory rates are preferred today; this was an inverted pattern in the past. You will find this in the scientific literature today. The aim is also to keep the patient normoventilated, so we often observe cerebral oximetry. Of course, in extreme cases with lung volume reduction and lung transplantation, a degree of hypercapnia may be accepted.

Is there some special fluid administration protocol for your patients?

The adopted lateral decubitus position can compromise pulmonary and cardiovascular physiology. Moreover, with one-lung ventilation and perfusion of a non-ventilated lung, the patient is positioned on the steep side of the oxygen dissociation curve. Our lung transplant patients remain very “dry,” receiving cristalloids, as ventilation is favored over perfusion; this prevents the occurrence of shunts. We want to prevent the lung oedema which puts the success of the procedure at risk; they are thus given diuretics as well as Mannitol so that the excess fluid can be excreted.

Is there any important post-operative protocol you wish to mention?

Yes, adequate analgesia post-operatively is of the utmost importance in order to optimize the patient’s respiratory function and facilitate coughing up secretions from the lungs. We like to keep the patient’s Visual Analog Scale (VAS) level between 1 and 2. Thoracic epidural with a mixture of bupivacain and opioids is usually given.

What are the most common complications of lung transplantation?

Hemorrhaging is the most common, followed by loosening of the anastomosis sutures.

What is it that you find of importance with an anesthesia system?

We have a great need for an excellent ventilator. When we saw and received information about the MAQUET FLOW-i, we found that it was easy to understand and powerful; we like the leakage compensation via the circular circuit; today, we sometimes underventilate our
patients because of lack of ventilatory power; what consequences does this have for our patients? The volume reflector is, theoretically, a very attractive feature as one does not need to interrupt ventilation, as it is the case in a leaking bellow. It is important that we have an alarm when the oxygen level begins to increase, in leak situations. The challenge will be to educate users in not seeing a moving bellow and relying on the safety feature of this technology.

**References**


**Biographies**

Dr Anne Westerlind, MD, PhD is former Chief of the Department of Cardio-thoracic Anesthesia and Intensive Care at Sahlgrenska University Hospital, in Gothenburg, Sweden. She is clinically active in the department and she has also held, since 2007, the position of Representative of the Swedish Association for Anesthesia and Intensive Care (SFAI) at EACTA (European Association for Cardio-thoracic Anesthesia), and has thereby worked on the European guidelines within thoracic anesthesia and thoracic intensive care.
Obese and morbidly-obese patients – addressing the challenges of perioperative ventilation

Since the last issue in which a Spanish anesthesiologist was interviewed, Critical Care News has been focusing on certain high-risk patient groups and decided to meet with three clinicians specialized in anesthesia for the obese and morbidly obese patient, to hear what they had to say about the challenges they face in terms of peri-operative ventilation for this patient group.

Critical Care News first met with Dr Jan Paul J. Mulier, MD, PhD during a congress in Austria. Dr Mulier is Founder of the ESPCOP (European Society for peri-operative care of the obese patient) and works at Sint Jan Hospital in Brugge, Belgium.

It was also interesting to travel to the United States and to meet with two anesthesiologists specialized in Bariatrics to hear what they had to say. Dr Jeremy Collins, Chief Assistant Professor of Anesthesia at Stanford University Hospital and Dr Robert H. Pinsker, Medical Director of Anesthesiology at El Camino Hospital, both in Silicon Valley’s Palo Alto in California, related their experiences in this field.
Dr Robert H Pinsker, MD, JD

Are you seeing more obese patients presenting for surgery? How does this affect their care as a patient group?

Dr Robert H Pinsker: At our hospital, we are definitely seeing an increased number of morbidly-obese patients, partly because we are an accredited bariatric centre of excellence. Bariatric patients are thus directed here for quality as well as insurance reasons. However, the generic literature, but not necessarily the medical, suggests that obesity may not be growing among adults, and yet we seem to be seeing an increased number of obese patients in our practice; it definitely appears to be on the increase in children. These patterns entail difficult airway management and ventilatory issues. An extensive number of spinal patients, for example, are often obese and as many as half will require surgery in the prone position, which can lead to very complex ventilation issues. But it’s not just this area that is problematic. Obese patients can be found scattered throughout all specialities, not only in bariatric surgery.

How different are these patients and how do these differences affect the anesthetic process?

Obese and morbidly-obese patients can be anatomically and physiologically challenging. Studies suggest they have a closing capacity that is significantly different, for example. They also have atelectasis when awake and standing, which, of course, is aggravated by the anesthetic process.

With general anesthesia, the first major concern is securing the airway either before or after the patient is induced. When an obese patient is under MAC (Monitored Anesthetic Care), i.e. sedation, their higher incidence of Obstructive Sleep Apnea (OSA) presents an issue of less airway control, despite the fact that one is avoiding general anesthesia. Nevertheless, it’s general anesthesia that gives the most cause for concern; absent awake intubation, one must make certain that there can be successful induction followed by successful mask ventilation and, ultimately, intubation.

What are your challenges with intubating these obese patients?

When one suspects a patient might be difficult to intubate once induced, one must also ask whether that patient might also be difficult to mask ventilate. Avoiding the so-called “cannot mask, cannot intubate” situation is critical, but, fortunately, these are fairly small in number.

What considerations would you normally implement to optimize ventilation during the maintenance phase?

The anatomical and physiological profile of an obese patient means that one wants to try to maintain the patient in a modified upright position. Unfortunately, this is not possible in most of the cases we see today, including bariatric surgery. In fact, one is expected to be able to place the patient in a fairly steep Trendelenburg, or head down, position. What’s more, many procedures are done laparoscopically, during which the increased intra-abdominal pressure compromises the functional residual capacity of the lungs. However, one can usually accommodate for this. In most patients without additional underlying lung disease, positive pressure ventilation, usually including end expiratory pressure, often solves the problem.

Can you give a specific example that illustrates the ventilatory challenges you face for these patients?

As a cardiothoracic anesthesia specialist, I can say that an obese patient necessitating a pulmonary lobectomy would pose special challenges because we have to be able to provide one-lung ventilation.

One would typically start by obtaining baseline pulmonary function testing. However, this is not always reliable because it doesn’t fully anticipate ventilation perfusion mis-match once a lung is collapsed. In addition, once an obese patient is in the lateral position, even before a lung is collapsed, his or her physiology can change dramatically, and this can lead to having, at times, to abort the procedure. Obviously, that is something nobody prefers to see occur. These are all challenges that we need to handle and we have a number of options available. We can apply different degrees of pressure to one or both of the lower and the upper lungs, for example, although with the collapse of the operative lung, we generally prefer not to see peak pressures higher than 10 cm of water. Some, however, can tolerate more than that.

Adjusting the gas flow rates or altering the inspiratory ratios are additional alternatives. Note, however, that applying end expiratory pressure often makes things worse, not better. We’ve also tried different maneuvers with bronchial blockers (instead of a so-called double-lumen tube), including application of pressure via the blocker. Each patient can present very much a “work in progress”, so to speak. Each patient responds differently, so there’s no standard formula that works every time. That’s a challenge in itself.

Many obese patients suffer from atelectasis even when upright and awake. Do you systematically perform recruitment maneuvers in these patients using a standardized protocol?

That’s an interesting question. The whole concept of employing recruitment maneuvers is fairly new to...
anesthesiologists, at least in the United States. But I feel that many of us have been doing these maneuvers for years without really knowing what to call them and assigning them a specific name.

Please tell us about your recruitment protocols. What difficulties, if any, do you experience?

In the case of a patient who is not undergoing pulmonary surgery, there is “no surgeon in the chest”, so to speak, and one has the option of intermittently taking the patient off the ventilator in order to manually attempt one or more recruitment maneuvers. One such method involves maintaining high pressure for 5 to 10 seconds, while keeping a close eye on the hemodynamics, which in obese patients can be negatively impacted very rapidly.

Where thoracic surgery is underway, one must communicate with the surgeon at all times in order to make certain that whatever maneuver is attempted, it does not impact the surgery negatively. In a severely ill patient experiencing difficulties with oxygenation or otherwise poorly tolerating one-lung ventilation, one may need to request that the surgeon stop at least momentarily in order to permit reinflation of a collapsed lung.

What can lead to post-operative ventilatory complications in the recovery room and how can the risks be diminished?

Total airway obstruction is the main risk. One wants to avoid transporting morbidly obese patients to the recovery room who are still moderately sedated and/or asleep. It is occasionally necessary nevertheless, however, and extubating anesthetized patients is what we call deep extubation. In these cases, it is particularly important that the patients be assisted with oral airway devices that stent or maintain open their upper airways.

Additional, more specific problems encountered with obese, neurosurgical patients include high intra-cranial pressures, so one may not want increases in blood pressures of these patients. Nor does one want such a patient to be coughing or bucking on the intratracheal tube as they emerge from anesthesia.

While one can’t guarantee a smooth emergence from anesthesia in obese patients, one way to help affect it is with opiate administration. Titrating in doses of a short-acting opiate can get
the patient to the point where all the other anesthetics can be discontinued, including the gas anesthetics. If there’s no other medication on board, one can actually wake most patients up with the endotracheal tube in place and absent coughing or bucking.

The problem is that, because opiates remain in a patient’s system, obese patients who have received these drugs and transferred to the ICU or ward can become re-sedated, or what we label re-narcotized. Moreover, a lot of these patients are not prone to voluntarily breathing deeply. In other words, sedation makes it difficult to “recruit” or re-open collapsed alveoli. Therefore, increased atelectasis in addition to an already low functional residual capacity can become disastrous.

One must encourage patients to perform their own recruitment maneuvers, in other words, to work every hour or so against a certain positive pressure. There’s nothing fancy about this technique; patients can do it on their own, without a machine – one such maneuver involves simply taking a big breath and holding it.

What mode of ventilation do you find most effective for obese patients?

The Pressure Support mode. We use this for non-intubated patients who have an LMA in place, but also for the intubated and obese who are undergoing short procedures. We’re able to keep them spontaneously breathing so they’ll be easier to wake up without having to administer muscle relaxation. Without Pressure Support, you often can’t maintain proper oxygenation.

We’re convinced that Pressure Support needs to be almost universally used in such cases. We have it at the hospital and would also like it at our out-patients surgery center, to where most of these patients come.

What do you view as the limitations of existing studies addressing perioperative ventilator challenges for the obese and morbidly-obese? Are enough patients being included?

Here I have to give you a somewhat empirical answer. I focus on reading anesthesia literature, which, in the U.S., largely consists of two main journals. We also reference current textbooks and exchange the occasional letter on the subject, but we don’t read a great deal of international literature. I’m not an expert on judging the validity of studies either.

Having said this, I don’t think there’s a scarceness of literature addressing perioperative ventilatory issues in obese patients. On the contrary, I think everybody in the States acknowledges that these are important issues, particularly regarding the need to address the relevant problem of OSA.

Biography

Dr Robert H Pinsker, MD, JD, Robert Pinsker, MD, JD is a double board certified physician as well as attorney who currently specializes in anesthesiology and anesthesiology program management.

In addition to being trained in and having practiced for many years the sub-specialty of cardiothoracic anesthesiology and critical care medicine, from 1995 to early 2004 Dr Pinsker practiced intellectual property law with the Palo Alto-San Francisco law firm of Flehr, Hohbach, Test, Albritton & Herbert, LLP. In this capacity, he secured intellectual property portfolios for a number of medical device start up companies and served on numerous Scientific Advisory Boards.

Subsequently, Dr Pinsker became a consultant in medico-legal administrative and medical program management. Presently, Dr Pinsker serves as the Medical Director of Anesthesiology at El Camino Hospital and Kindred Hospital, S.F. Bay Area, in Hayward, as well as the Medical Director of the El Camino Surgery Center.

Dr Pinsker is the founder of multiple companies, including Fidere Anesthesia Consultants, Inc., Pacific Physicians Medical, Inc., Doctors Billing Service, Inc. and Fidere Capital Investments, LLP.
Dr Collins: I have worked in Europe and the US and I can say that the situation is the same in both. The idea that obese and morbidly obese patients are only found in America is just not true.

However, I believe that the US is more likely to see the emergence of a small, super morbidly-obese population. We are now also seeing more numerous younger patients presenting with obesity, as well as more adolescents needing bariatric surgery. Interestingly, the concerns that bariatric surgery in the young leads to malabsorption issues that affect their subsequent development appear to not be the case. The fact that this intervention may help prevent diabetes and irreversible cardiac defects in patients at risk means that it is now viewed as being worthwhile. In terms of a national health issue, the long-term health savings can be significant. Another interesting fact is the preponderance of female patients presenting early, perhaps due to aesthetic reasons. Males tend to present at an older age with problems related to the co-morbidities associated with their obesity.

Dr Collins in his office at Stanford University Hospital, Department of Anesthesiology

Please give us your views on obesity demographics. What changes have you seen over the last 15 years?

I’ve seen some correlations where ventilatory parameters improved as patient hip/ratios went down.

We also know that women have a higher BMI partly due to the fact that they’ve got larger lower bodies. For an anesthesiologist, weight centered around the lower half of the body is not really a major concern.

Another interesting fact is the preponderance of female patients presenting early, perhaps due to aesthetic reasons. Males tend to present at an older age with problems related to the co-morbidities associated with their obesity.

What about the different measurement tools used in diagnosing obesity? Which one, other than BMI, is used and do they help the practitioner in assessing the patient’s ventilatory parameters?

I think that a lot of the co-morbidity associated with obesity is related to truncal obesity. As hip/waist ratio is a better reflection of truncal obesity, I think we will find that it offers a closer correlation to poor ventilation and sleep apnoea than BMI, for example.

Do you find that the obese patient in anesthesia is a good model for other high-risk groups?

Yes, that’s certainly the case. Firstly, the know-how with the obese helps in dealing with “normal” patients as well. If you are confident in managing obese or morbidly-obese patients with exaggerated pathophysiology, you will find it much easier to deal with lean patients.
Secondly, when you encounter a high-risk patient in another speciality, you won’t have to re-think everything in terms of managing their airway, the equipment, the ventilator, the operating table, etc. You will be used to a more complex situation and the high performance equipment that will help you handle it.

But it seems like even those of us who are not dealing with obese patients on a regular basis will soon have to do so. I believe that a study made in Pennsylvania in 2007 suggested that 1 in 12 patients had a BMI of over 40. And in a cohort of 20,000 patients, something like 365 had a BMI of over 50, that is one per day in the operating room having non-bariatric surgery.

**What measures would you consider implementing to optimize ventilation, bearing in mind the anatomical and physiological profile of obese patients?**

Their reduced functional residual capacity means that their tendency to desaturate is much greater than in the “normal” patient. Mass loading of the chest and abdomen can be partially offset by positioning in a more upright manner. Early control of ventilation with adequate paralysis prevents the poor tidal ventilation and subsequent desaturation that occurs with bucking on the endotracheal tube. This can be associated with extremely high airway pressures and is not well tolerated by these patients.

In the super morbidly-obese patient (BMI 50-70), many of these problems are exacerbated. Moreover, most bariatric cases are done laparoscopically and the increased intra-abdominal pressure compounds those difficulties that I just mentioned.

However, we sometimes have a mechanical advantage in the fact that a lot of the surgery is done in the reverse Trendelenburg position. This off-loads some of that muscle and fat from the abdominal wall and makes ventilation a little easier. But in many gynecological procedures, the opposite applies because of the need to place the patient head down. If you have a morbidly-obese patient having surgery in the Trendelenburg position, it may be impossible to ventilate them effectively. We may have to tell the surgeon “The patient won’t tolerate this degree of tilt. We maybe have to think about doing an open procedure.” This is far from ideal, however, as it is going to mean that the patient’s post-operative course is going to be that much more difficult.

**What cases do you consider to be most challenging when caring for the obese?**

The non-elective, trauma situation. From an anesthesia point of view, this is a big contrast to bariatric surgical procedures, where we have the situation under quite good control. An obese to morbidly-obese person involved in a car accident is definitely more challenging in terms of airway management, respiratory function and vascular access. With a trauma patient having suffered fractured ribs and perforation of the lungs, leading to pneumo and hemothorax, for example, their airway pressure is likely to be significantly higher than in the elective situation. It may then be that you have to generate quite high pressures in order to expand the lungs effectively and maintain them open.

**What challenges arise when patients are put to sleep and given muscle relaxation?**

Lean patients get some degree of atelectasis, particularly when you give them 100% oxygen, but this is often even more dramatic in the morbidly obese, where up to 20% atelectasis is more common. Although the 100% oxygen used to pre-oxygenate will contribute to atelectasis, the priority in morbidly-obese patients is to maximize the efficacy of pre-oxygenation - this will lengthen the period of time following anesthetic induction before hypoxia develops. The literature suggests two simple approaches.

One is to use some degree of head elevation, for example reverse Trendelenburg or beach chair position. The other is to use CPAP in the pre-oxygenation phase. Pre-oxygenation with 100% oxygen in the head-up position combined with a period of CPAP has been proposed as a means of prolonging the time to desaturation even more.

**What ventilating mode would you use in order to minimize eventual post-operative ventilatory complications?**

In the future, it might be worthwhile investigating whether we could minimize atelectasis by using 80% oxygen and maximize the time to desaturation by using CPAP. Obese patients also have around 10-fold more likelihood of OSA, so many of them are prescribed CPAP anyway. However, compliance rates are only about 50%, because patients often consider CPAP uncomfortable, noisy or claustrophobic. Nevertheless, I think we would see a benefit in terms of reduced atelectasis with just 5 or 10 minutes of preoperative CPAP in the upright position, either in the preoperative area or in the OR before we put them to sleep.

I believe that we are seeing increased awareness that CPAP is also safe to use in the immediate postoperative period, and that can be as soon as the tube comes out.

However, the logistics of giving CPAP in the post-operative unit are difficult. In the future, what we may see is a cohort of the severely obese population – BMIs of 70 and above – having some kind of nasal non-invasive ventilation, both in the preoperative and the postoperative areas.

Naturally, we don’t want to put patients at increased risk of aspiration by giving so much gas into the upper airway and the esophagus that they then get gastric dilation and aspiration. But if we do it in a controlled way with comfortable nasal strapping or an oro-nasal mask, and we can see the pressures on the ventilator, we could avoid this worry.

**How important is ventilator performance in overcoming the special physiological challenges you meet?**

Ventilator performance is important - being able to generate higher peak pressures to control poor lung compliance or high intra-abdominal pressures is a good example of specific...
With a very obese patient, weighing 900 pounds, for example, who is on high ventilation settings and a lot of PEEP, it is highly desirable that the quality of ventilation is not interrupted during transport between the OR and ICU. Having an inferior ventilator in the OR can lead to sudden hypoxia, a reduction in tidal volumes and an increase in atelectasis.

Could you tell us something about the recruitment maneuvers you recommend. What is your current clinical practice in this field?

PEEP of around 10 is one aspect of my current practice. But if you have good respiratory monitoring from your ventilator in the OR, you may be able to find a more optimal PEEP setting. I recall a study looking at recruitment maneuvers that I believe showed going up incrementally from 10 PEEP to 15 then to 20. This improved PO₂ and compliance as well.
Regular recruitment maneuvers using PEEP thus seem important if you want to minimize atelectasis.

In addition, there may be a subset of patients, e.g. those with very heavy chest walls, that might need PEEP pressures very much higher than the levels regarded as “conventional” by many physicians. Levels perhaps even higher than the 50 centimeters of water that I mentioned earlier may be required to expand the lungs effectively and keep them open.

I also feel that the benefits of such recruitment maneuvers may sometimes be lost at the end of surgery. We should be better at maintaining a certain degree of recruitment post-operatively in the first 24 hours, the period when these patients are at high risk of episodic desaturation. Receiving more direct input from critical care staff or respiratory therapists would be beneficial in terms of addressing such post-operative issues.

What ventilator modes do you find to be useful in other phases of the procedure?

I find Pressure Support most useful towards the end of the surgery, as I’m trying to get the patient to return to spontaneous respiration, rather like an extubation maneuver. In the morbidly-obese patient, who may be a difficult intubation and have OSA, it is important to make sure that they are adequately awake before you extubate to avoid early airway obstruction and avoid a need to use positive pressure mask ventilation, which may put the new anastamosis under strain.

How important is patient positioning in helping to optimize peri-operative ventilation?

I spend up to 10 minutes making sure the patient is in a very good position for intubation. But we then take away that positional support after intubation and therefore face problems lifting them back into that same position later because they are so heavy. As we cannot achieve the same ideal position for extubation that we can for intubation, the conditions are non-ideal at the end of the case. We thus need to be absolutely sure that the patient is adequately awake before we extubate. That relies on good anesthesia so that patients can tolerate the endotracheal tube without coughing and bucking and pulling it out. Whatever ventilation mode you are using, it is important that patients can breathe comfortably on the ventilator to guarantee their airway, and so that they won’t panic.

If we come back to the issue of ventilatory modes for these patients, is there anything you would like to add regarding the end of the procedure?

A good ventilator and good ventilation modes are important. There’s nothing worse than losing good intra-operative tidal volumes with good PEEP at the end because the patient is fighting the ventilator or because you are trying to return to spontaneous ventilation in the supine position, which is not a good position for obese patients. A good spontaneous mode of ventilation that is assisted is very useful at the end of the act when you want to maximize tidal volumes and minimize the occurrence of sudden atelectasis.

Biography

Dr Jeremy Collins, MD, Chief Assistant Professor of Anesthesia, is originally from the United Kingdom, but has been established in California for the past ten years. He is affiliated to both Stanford University Hospital and Lucile S. Packard Children’s Hospital, both in Palo Alto, CA. He works closely with Dr Jay Brodsky, Professor of Anesthesiology at Stanford University Hospital, and is the author of numerous publications in the field of airway and anesthesia management of the obese patient.
Which special ventilation aspects do you consider with respect to anesthesia of the obese patient?

When ventilating obese patients, you should not only look at the thoracic compliance but also at the abdominal compliance. By solving the abdominal problems, you also solve the ventilation problems. That is the approach I have been applying in the last two years instead of adapting the ventilator settings only. Traditionally, the laparoscopic surgeon does not care about ventilation, and we, anesthesiologists do not care about surgical workspace. Therefore the abdominal compliance issues were believed to be the realm of the surgeon only. In my view the diaphragm should no longer divide the body between abdominal surgeons and anesthesiologists. My aim today is to see if I can change the abdominal compliance to improve the surgical workspace and the ventilation at the same time. Helping the surgeon with his problems is the reason for our existence as anesthesiologists in the past. We developed our own activities and responsibilities to the patient and forgot the surgical problems. We as anesthesiologists have to improve not only the anesthetic outcome that is already very good but also the surgical outcome by using our knowledge as an applied physiologist. This new way of thinking I call the trans-disciplinary approach that goes one step further than team work.

What methods do you apply when ventilating an obese patient who might be difficult to ventilate?

When I have an obese patient who is difficult to ventilate with high airway pressures, I have several strategies that I can apply: The first one is to give them continuous sufficient muscle relaxant allowing the abdomen to relax maximally and lower the intra abdominal pressure (IAP) which improves ventilation. Another aspect is positioning of the patient in the beach chair position. By flexing the legs and giving anti-Trendelenburg inclination, we improve the abdominal compliance and lower the IAP. This creates more space for the lungs and lowers the airway pressures again. Beach chair position also prevents also venous stasis. A patient with a BMI of 60 or more has to loose 20 kg or more before the operation to make it easier to insufflate the abdomen and to ventilate the lungs. Inflating the pneumoperitoneum to a minimal surgical workspace instead of a fixed certain pressure means frequently a lower intra abdominal pressure and hence an easier ventilation. In a last aspect we accept higher end-tidal CO₂ as this stimulates the cardiac output and the wound perfusion and requires a lower ventilatory minute volume.

What does high ventilation performance in anesthesia mean for you?

We can start by looking at the different ventilation modes that come to us from the ICU. For example, Pressure Support was developed to facilitate weaning and to improve synchrony between the patient’s breathing and the ventilator. In anesthesia, we didn’t have this problem of synchrony. For a long time we therefore didn’t look at these modes. But some of these modes can also improve ventilation, even under muscle relaxation by adapting them to anesthesia. New modes can be further developed like Volume Support or Proportionally Assisted Ventilation. We can look at the speed of changes in gas concentration, needed at induction or at the end of the procedure, something most anesthesiologists are concerned with and where improvements are still possible. Opposite to speed we can look at the efficiency of gases, inhalation vapors and absorbers used all aspects the hospital is more concerned with. We can look at the measurement capacities beyond pressures and volumes. Lung compliance for example is not linear which makes it difficult to use. Many other parameters can be measured but without clinical meaning they risk being more fancy than useful. Safety aspects in ventilators still need further improvements. Pressure controlled ventilation is dangerous for volutrauma when no volume adaptation exists and the abdomen is suddenly deflated. Pressure support can also be dangerous for volutrauma when the patient regains his strength. Volutrauma is also possible with most anesthesia ventilators when by human error one forgets to switch from manual to controlled mode with a closed APL valve or when the exhalation tubing is blocked. The safety frog we developed as an external device or built inside the ventilator can prevent this.

Why do you think there are some who say that there is no correlation between obesity and peri-operative ventilatory complications, whereas other studies show the contrary?

One reason is that not enough studies have been done on the obese and the morbidly obese patients with respect to this point. The other reason is the fact that BMI itself is not a good predictor for the risk of metabolic syndrome with its associated cardiac and pulmonary complications. The waist to hip (W/H) ratio predicts the existence of this syndrome and the complications of obesity as it better describes the fat distribution. A W/H ratio above 1,5 means that all fat is situated in the abdomen, increasing the intra abdominal pressure and making ventilation very difficult. This android (W/H > 1) fat distribution is more frequent in men than in women who tend to have more frequently a gynoid (W/H<1) fat distribution.

It is also a fact that keeping the surgical procedure short for the obese patient...
has a positive impact on outcome. The longer the procedure where you keep them intubated and mechanically ventilated, the worse the outcome is.

**What about the situation of atelectasis in these patients and how do you ventilate these patients during a routine operation?**

Obese patients have atelectasis even while awake and standing. They are not able to breathe deeply as the diaphragm is permanently elevated. Lying flat is very bad and anesthesia induction should start again in the beach chair position. CPAP should be available at pre-induction and during induction, followed by ventilation with PEEP. The same is true at the end of the procedure. Most anesthesia ventilators do not allow giving CPAP by mask, something that needs to be incorporated. Techniques do exist for raising tidal volume and performing recruitment maneuvers. However, these require manual intervention with interruption of the PEEP level and this can be very bad in preventing atelectasis. The effect is a nice oxygen saturation. However, we are not sure that recruitment does not overstretch and damage the lungs at the same time, and thus compromising the outcome. After induction, a volume controlled or a pressure controlled mode can be used always with a low PEEP. I prefer Volume Control for its safety and will use Pressure Control if airway pressures are very high. At the end of the surgery I always switch to Pressure Support with PEEP even with full muscle relaxation. Besides a better oxygenation and a more physiological breathing, it allows us to titrate the Sufentanil dose to a maximum without impairing the respiratory rate and allowing a patient to wake up pain free.

**Is the obese patient population a good model for other high-risk patients presenting for anesthesia?**

Yes, of course. Understanding the physiology of the obese to extreme obese patient helps improve care of other high-risk patients with comparable organ problems. The patient with acute abdominal compartment syndrome, the patient with low cardiac output, the patient with right ventricular failure, the patient with low oxygen saturation are just some examples of high-risk patients with comparable problems.

Aspects we have learned from morbidly obese patients and that we now use in other cases are the way we ventilate patients with low oxygen saturation or with high airway pressures, the way we improve skin perfusion and diminish wound infections; the way we prevent postoperative surgical bleeding by increasing blood pressure and cardiac output are just some examples.

**What about the different phases of the anesthesia? Do you encounter any difficulties?**

One must differentiate between difficult intubation and difficult mask ventilation. By elevating the head and the thorax of the patient during induction the intubation is not more difficult than in the non-obese patient. On the other hand, mask ventilation will remain difficult even with the beach chair position, the mayo cannula and two hands available to hold the mask. Obese patients are also at higher risk for aspiration, making mask ventilation frequently dangerous, and therefore not performed.

During induction, ideal body weight is used to calculate the agent dose, while during maintenance a higher agent dose than ideal body weight is needed. You can try to calculate drug doses for every patient but will need to adapt them according to the measured effect.

Good muscle relaxation is important in patients with small abdominal compliance; this is most frequent in the android male type or young girls who have not yet been pregnant or who never have had a laparotomy or laparoscopy. Full muscle reversal is very important so that he/she can gain maximum muscle power while being fully awake. This is crucial to have them breathe deeply. Pain control is also very important and should start before the end of the operation. Loco-regional anesthesia is ideal but more difficult to perform in the obese.

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Dr Jan Mulier, MD, PhD, anesthesiologist, is founder of the ESPCOP (European Society for peri-operative care of the obese patient) and Chairman of the Department of Anesthesia at Sint Jan hospital in Brugge, Belgium. He is the author of numerous publications concerning aspects of peri-operative ventilation and has done extensive research in this field.
Following the spring issue in which two European anesthesiologists were interviewed, Critical Care News was interested in meeting yet another clinician, this time in Spain, to hear what he had to say about the most important considerations in peri-operative ventilation mechanics for a wide range of patients.

The University Hospital of La Paz is situated in the Fuencarral-El Pardo district of Madrid and is a multi-disciplinary public teaching hospital with focus on maternal and infant health care. La Paz is a reference hospital for all of Spain, as well as a reference burn center for pediatrics.

Dr Javier Garcia Fernandez has done extensive research in ventilation mechanics and has developed an anesthesia simulator, making it thus easier to explain the principles of a circle system, as well as the importance of certain principles that can have clinical implications.
How would you define high ventilatory performance in anesthesia and what criteria would you base it on?

In order to give an appropriate definition, I would refer to the use of all the available ventilatory therapeutics which are available in the ICU. Machines in the ICU have improved notably in the last ten years, but the advancement on anesthesia machines has not followed the same pace: here, there are limitations. However, we have today high risk patients entering the operating theatre, adults as well as children, elderly and the very young, with high morbidity and critical situations, such as critically ill patients, the morbidly obese, to name a few; among these are critical care patients necessitating surgery, whose status is thought to be improved by surgery. One special case is also very small children, who used to die several years ago but who, thanks to medical and technical advancement, are now.

Can you tell us about your professional background?

My residency was done at the La Paz hospital in Madrid, after which I worked for a year with adults in a general hospital. After that year, I returned to La Paz hospital and have been working with children; I have also earned an MBA in Sanitary Business Administration. I have been running the surgical Intensive Care Unit in pediatrics for the past 2 years. I am working both in the ICU and the department of anesthesia, and have been focusing on mechanical ventilation for the past 8 years.

Can you tell us about your research and publications in the field of mechanical ventilation?

My first research in anesthesia and mechanical ventilation, was about the use of Pressure Support inside the operating room. I wanted to try and transpose the knowledge from the critical care unit into the world of the operating room, looking at the differences between the used ventilatory modes, the clinical approach in using these modes, how one does the machine settings, and so on. The first point was how to convince the rest of my colleagues on the use of the different ventilation modes which were of benefit to our patients and to simplify these techniques for the use in the operating theatre. After that I published two more articles on how to set and use Pressure Support in the OR for children, as well as the differences in PEEP settings between adults and children in the OR. Most clinicians don’t want to use PEEP in the OR with children, because they are afraid of the pressures they may be using, even though they regularly apply them in the ICU. I realized that focusing on transferring this knowledge from the ICU to the OR would make its use easier.

How would you define high ventilatory performance in anesthesia and what criteria would you base it on?

In order to give an appropriate definition, I would refer to the use of all the available ventilatory therapeutics which are available in the ICU. Machines in the ICU have improved notably in the last ten years, but the advancement on anesthesia machines has not followed the same pace: here, there are limitations. However, we have today high risk patients entering the operating theatre, adults as well as children, elderly and the very young, with high morbidity and critical situations, such as critically ill patients, the morbidly obese, to name a few; among these are critical care patients necessitating surgery, whose status is thought to be improved by surgery. One special case is also very small children, who used to die several years ago but who, thanks to medical and technical advancement, are now.
This group of patients is that it is difficult to ventilate them. If one does not have the same ventilatory performance in the operating room as in the ICU, then ventilating becomes very difficult. What percent of the cases represent pre-term neonates? Nowadays, I must say 60%. The great majority of neonatal pathology has to do with premature babies. With each technological advance in neonatal care, one was able to advance, or decrease the survival weight with an extra 500-600 grams. Today, very tiny babies are operated on more often than healthy neonates, with conditions such as pylorus defect or myelo-meningocele. These procedures can be done without complication on full-term babies, but on the very tiny premature who have multi-pathologies, intestinal, renal, respiratory and hepatic it is a challenge.

**When speaking about neonatal surgery, do you define these cases as full term neonatal or pre-term?**

This question seems to me very important. From the point of view of mechanical ventilation, there are anesthesia machines which are not capable of delivering the technology needed, based on the two fundamental conditions: the weight of the patient and the condition of the lungs. If the baby weighs less than 3 kilos, then it is often difficult to ventilate, even in the healthy lung. It can present altered lungs, pulmonary distress or hyaline membrane syndrome, something which worsens the condition. The main problem with this group of patients is that it is difficult to ventilate them. If one does not have the same ventilatory performance in the operating room as in the ICU, then ventilating becomes very difficult.

**What are the most commonly performed surgical procedures on neonates?**

Most often we see congenital pathologies, such as esophageal atresia, or diaphragmatic hernia. But premature also undergo surgical procedures for necrotising enterocolitis and intestinal ischemia, who in the past would die, and who today survive thanks to advances such as intestinal transplants, thus allowing them to go forward in their development. The number and success of these transplants is increasing, however, many of these children remain in a critical state, as they often have multiple pathologies, renal, hepatic, intestinal.
They are often in much more critical condition than the healthy neonate.

**These children often end up in neonatal ICU post operatively. How important, according to you, is the continuity of high ventilation performance with respect to their outcome?**

This is absolutely crucial. It can mean the difference between survival and death. Whatever ventilatory changes occur, or disconnection, not being able to maintain a stable PEEP over time, can have the result of damaging their fragile lungs; if these patients do not die peri-operatively, they may well do so post-operatively if there is no continuity.

**You have extensive experience in pediatric anesthesia. In which way do you think pediatric anesthesia practices can pave the way for optimal adult anesthetic practice? Can pediatric anesthesia provide guidance to the industry for developing machines able to handle the coming challenges in adult anesthesia?**

I believe this question is of the utmost importance. The pulmonary physiology of neonates gives us many answers. In the last 4-5 years, there have been questions concerning which tidal volume should one use in adults with distressed lungs? The recommended VT is the same for these patients as for neonates, that is to say 6 ml/Kg. The other aspect is the use of PEEP. The best way of avoiding atelectasis is the use of PEEP. You need to have a good understanding of neonatal pulmonary physiology to prevent atelectasis which occurs in all neonates; this knowledge can lead to knowledge on how to respond optimally in adults. Neonatal lungs are the perfect model for respiratory distress in adults. The dynamic compliance of the lungs of a neonate (3 ml/cm H2O) is 6 times less than in a highly distressed adult patient (20 ml/cm H2O). If an anesthesia machine can provide good ventilatory performance for a neonate, then it will be able to adapt perfectly to the adult patient needs, even in the case of the highest pulmonary distress. Pressure delivery in the case of bronchospasms can also be applied to both categories. One can also take the example of the obstetric patient whose lungs tend to easily collapse, much as the neonate who always suffers from atelectasis. Good recruitment possibilities in neonates ensure the same for adults.

It is astonishing to me that more anesthesiologists do not wonder about the “potency” or power of the anesthesia ventilator. They often speak about the color of the windows on the interface, the size of the buttons, the alarms, how big or small, how easy it is to move the machine… But the power of the ventilator… Why is that of importance? Much in the same way as in automobiles, acceleration can mean the difference between life and death in certain critical situations, such as bronchospasm, asthma, respiratory distress. The answer to these is the access to a full range of settings, like in the ICU. This will ensure proper ventilation for “this” patient. For “this” patient, in this critical situation, this aspect of high performance in ventilation will be the most important consideration. Most patients have enough with a PEEP setting less than 20 cm H2O. But in certain cases, going above 25 cm H2O will be a life-saving strategy, especially during a pulmonary recruit manoeuvre. These aspects have to do with patient safety. Maybe not many will need it, but for the one who will need it, it will be crucial! It represents a guarantee for the majority of the patients. It is also a question of confidence for the anaesthesiologist, trusting this particular machine. With a traditional circuit system, one often goes over to manual/spontaneous ventilation in pediatrics, at the end of a procedure, because one feels to have more control. This has also disadvantages. Mechanical ventilation is security for all ranges of patients.

Dr Garcia has developed an anesthesia simulator which helps in understanding ventilation mechanics in a circle system.
With respect to acquired knowledge in the field of anesthesia, what aspects would you consider as important to transmit?

Inevitably, patient safety is the top question. One must know the basics of mechanical ventilation. But that is not enough. One must also understand the differences between the circular circuit versus the open circuit. Lack of this knowledge entails many extra problems for the patient and the clinician. In the future, companies will “automatically” solve these questions for the practitioner, even if one doesn’t master these aspects, one will be able to use the machine. However, it is necessary to have a minimal knowledge of advances in mechanical ventilation and physiological application.

Could you please describe the settings you would use in a 3 Kg healthy neonate?

Induction would generate respiratory arrest and after intubation, one has a situation of full lung atelectasis. In order to counter this problem, one has to increase PEEP after reaching hemodynamic stability, 5 by 5 cm H₂O, all the while maintaining a driving pressure of no more than 15 cm H₂O, until a maximum peak pressure of 35 cm H₂O is reached, then with a PEEP of 20. Some neonates with severe distressed lungs often need a maximum peak pressure of 45 cm H₂O to open their lungs. By wanting to limit the driving pressure to 15 cm H₂O, you must then increase the PEEP to 30 cm H₂O. After which, you start reducing the pressure and set the proper PEEP, adapted to the patient. One needs to have a wide range of PEEP levels and maximum pressures.

Could you please tell us about what you think are the needed ventilation modes?

I have a very personal point of view regarding this matter. About 5 years ago, very many ventilation modes appeared. It is crazy. When you think about it, Volume Control is the most commonly used. But Volume Control is not enough; Pressure Control and Volume Control are mandatory today. Pressure Support is also beneficial for the patient not needing muscle relaxation. It is better for the patient, the anesthesiologist and is easy to use.
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liters of fresh gas flow, as one spends much more absorbent. The final reduction is much more expensive. And today, there are the risks of hypoxic mixtures. Some clinicians are however passionate about low-flow, but cost savings should be calculated. As a conclusion I would like to say that it is important for clinicians to have knowledge about mechanical ventilation, as it lies at the centre of patient safety. It is a powerful tool for avoiding negative iatrogenic effects on patients; one must have knowledge about the “open lung”, as well as all protective strategies in ventilation during anesthesia. The application of this knowledge has been shown to reduce mortality by 10-12%. These strategies should be applied to daily care.

What are your thoughts about low-flow anesthesia? What are the limits?

Low flow anesthesia is mandatory; but the limit is the safety of the patient. But there are no savings between 0,5 and 0,3 liters of fresh gas flow, as one spends much more absorbent. The final reduction is much more expensive. And today, there are the risks of hypoxic mixtures. Some clinicians are however passionate about low-flow, but cost savings should be calculated. As a conclusion I would like to say that it is important for clinicians to have knowledge about mechanical ventilation, as it lies at the centre of patient safety. It is a powerful tool for avoiding negative iatrogenic effects on patients; one must have knowledge about the “open lung”, as well as all protective strategies in ventilation during anesthesia. The application of this knowledge has been shown to reduce mortality by 10-12%. These strategies should be applied to daily care.

References


Biographies

Javier García Fernandez, MD, PhD
Anesthesiologist and Intensivist at the University Hospital of La Paz in Madrid, Spain, where he has been Head of the Department of Pediatric Surgical Intensive Care for the past two years. Dr García is also the creator of an anesthesia simulator called “Javierito”, which helps colleagues in understanding the implication of peri-operative ventilation mechanics in patient care. He has been doing research in ventilation mechanics for the past 8 years. Moreover, he has published articles in this domain.
The need for high ventilatory performance in anesthesia – perspectives from two clinicians in anesthesiology

Critical Care News has been lending its voice to intensive care doctors around the world in their efforts to publicize the many different research papers that bring to light the need for high ventilation performance in the ICU. Much progress has been made in this field over the last years, and the applications are many. In this respect, we wanted to raise the question of the same need in the field of anesthesia. That is why we met with two highly specialized clinicians and wanted to hear what they had to say about this.

The University Hospital or CHU of Montpellier, France, is a multi-disciplinary hospital with focus on education and extensive scientific research. Astrid Lindgren’s Children Hospital in Stockholm belongs to the internationally renowned Karolinska University Hospital.
Professor Capdevila has done extensive research in ventilatory mechanics and optimization of ventilation in anesthesia.

What, according to you, is high ventilation performance in anesthesia, and what are its specificities?

Professor Capdevila: That is, that respiratory management in anesthesia is making its baby steps, much in the same way as it was in intensive care, some 20 years ago. The two worlds are very different. In which way are they different? In intensive care, patients are in need of ventilatory assistance because of acute respiratory insufficiency, no matter what the cause. The world of anesthesia stands apart; why? Not only the ventilatory care of the patient is in focus, but also and foremost, the peri-operative care. Most of our patients, thankfully, have no major complications, and for these the main concern is to put them to sleep and to wake them up. However, some run greater risks and for these, the anesthesiologist has to take into consideration ventilatory, hemodynamic, neurological and renal aspects of care.

For many years, progress has been made in the field of monitoring hemodynamics and hypnotics, to the detriment of ventilation advances. What interested us was to have an SpO₂, EtCO₂ and maximal pressure. The second aspect, is the possibility of caring for a variety of patients, the one with ARDS, chronic bronchopathy, thoracic traumas, the one with severe asthma or sepsis; recent developments in the performance of anesthesia ventilators allow us today to give almost the same level of care as one gives with ICU ventilators in terms of pneumatic possibilities, with good trigger sensitivity, rapidly increasing pressure when in pressure modes. Today, anesthesia machines have pretty well all incorporated these features. This allows us to go much further in adequate care of these patients. In the past, these patients all had aggravated respiratory conditions upon leaving the operating room, with increased ARDS, an increase in pulmonary edema, diminished ventilation/perfusion ratio, etc. We have optimized this aspect of care today thanks to the advances made.

A recent survey tells about 95% of patients receiving anesthesia as being lung healthy individuals. Are you met with any challenges today in terms of ventilatory performance in anesthesia?

Professor Capdevila: Yes, there has been this recent survey done by the INSERM (French National Institute for Health and Medical Research) in France, relating that approx 95% of the patients are healthy in their lungs. However, an ASA-2 patient could present a severe asthma, at a young age, and thereby be a concern for the anesthesiologist. In the same way, an ASA-1 patient who undergoes spinal surgery, or who lies prone for several hours, which also poses problems due to positioning and this can affect ventilation needs peri-operatively. The ventilator must then deliver the same tidal volume which one has preset, with the possibility to correct the internal compliance of the machine. There are augmentations in PEEP, variations in the delivery of fresh gases, variations in resistance which make that there are many ventilatory changes in anesthesia; in the span of 45 minutes, one can have six different ventilatory conditions. What are the important elements in an anesthesia ventilator?

They are, dependability in the precision of volume delivery with a given pressure, adaptability with respect to patient specifics. An 84 year old COPD patient is not the same as an 8-month old infant, or a healthy 25 year old woman. Adaptability to varying surgical postures which can alter respiratory mechanics in the patient.

This brings us to ask the question concerning the needs and existing features of the modern anesthesia system versus the needs of ventilatory performance? What are the obstacles in increasing this performance?

Professor Capdevila: One very important aspect is simplicity. The anesthesiologist has several things to do at the same time. The anesthesiologist needs to look at the ventilation mode, fluids to be given, anesthetic and neurological parameters, and all this in concordance with the surgical constraints, and patient positions at a given point in time. The settings must be simple to make on the Interface, no submenus, or sub/sub-menus! They shall not be done in this case! But there is also an aspect relating to the modern-day anesthesiologist’s competence level and knowledge of ventilation.
They have extensive theoretical knowledge, however, most anaesthesiologists are light-years away from using special ventilatory modes, studies have shown this. Only 20% of patients have a PEEP level set, even though it has been proven that not setting a PEEP level leads to atelectasis already during the induction phase! Setting a PEEP level in the morbidly obese patient according to the size and weight is adopted knowledge that is in use; however, an active level of PEEP, that is to say 5 to 9 cmH₂O, is still only given in 7% of patients, thus exposing them to atelectasis and complicating their post-operative condition and rehabilitation. There is really a cleavage between the possibilities offered by anesthesia units today and the application thereof by clinicians. Of 3000 patients, only 25 are put on Pressure Support mode. Why? Because many anaesthesiologists still think that Pressure Support is only a weaning mode used primarily in the ICU. It is nevertheless used widely with laryngeal masks; we know this to be good practice. We also know that many small elderly ladies are under ventilated, whereas the morbidly obese patient is often over ventilated. The settings are not made correctly, due to a lack of knowledge in the field of ventilatory mechanics, dynamics and control. One ends up with “trivial” settings, or inadequate default settings.

Maquet has conducted a survey about anesthesia segments. They divided up the anesthetic acts into Routine, Complex and Complex Advanced. What are your thoughts about this?

Professor Capdevila: I think one should not address the anesthetic act as being routine, complex or complex advanced, but rather the peri-operative care which includes the anesthetic care as being so. There is no small anesthesia, we have already spoken of how a seemingly straightforward act can be complicated by a sudden ventilatory occurrence (asthma, laryngeal spasm or other). But this is a common question which we get from the Ministry of Health in France; we at the SFAR (Societe Francaise d’Anesthesie et Reanimation) explain to them that every act can become complicated and can turn to being problematic very fast!

What would you like to see as a development in anesthesia systems to meet your ventilatory needs?

Professor Capdevila: An anesthesia ventilator must be able to deliver precise volumes with certain given pressures, anesthetic gases, whatever the patient’s condition and surgical considerations. This is starting to become rapidly known as “normal ventilatory performance” in all existing units, from the small infant to the 250 kg patient. There are those exceptional cases—we have 3 cases a year – of the pre-term baby who has immature lungs, where we must bring in an ICU ventilator into the OR. But we manage most cases today. However, in the near future I would like to see target controlled ventilation with concentration objectives on all machines. Another development would be automatic FRC calculations which would give us a visual status of the patient’s lungs, with its compliance issues with respect to rising resistance values. It would allow adequate ventilation in the morbidly obese, the COPD patient, infants, etc. That should be the future of high performance ventilation in anesthesia.

Do you believe that high ventilation performance in anesthesia is important in your area of speciality?

Professor Lönnqvist: Yes, I do believe that ventilation performance in anesthesia today must pretty well match the quality of ventilation in intensive care. The patients I have are children where we do at times, use a very specific mode of ventilation, called High Frequency Oscillation; this is exceptional and I don’t think that it would be necessary for anesthesia ventilators to offer this mode. However, Pressure Support is a must. But there is more than ventilatory modes to speak of. My speciality includes the very smallest pre-term babies, weighing between 500gr-1000gr. Some of these babies are born with a defect which comprises a hole between the pulmonary artery and the aorta due to incomplete closure during foetal life; they have to undergo a procedure called “closing of the ductus” if they are to survive. One must be able to ventilate these small babies who have tidal volumes between 5 and 10 ml. It is important to have access to a system capable of delivering such small volumes, while supplying with precision, inhalation gases. This combination can be a problem. We also have to provide anesthesia to patients coming from the ICU and who necessitate the same adequate ventilation during anesthesia as they receive in the ICU. This is a central question.

Are the current anesthesia systems you have adequate in supplying this level of ventilatory performance?

Professor Lönnqvist: Modern anesthesia ventilators offer good solutions for bigger patients all the way down to the full-term infant. The problems we encounter are when the babies are under 1500-2000gr; there exists today, no good alternative which can deliver good, precise ventilation with safety to this patient category. The SERVO 900-C has been used, even though it does not offer the more “modern” ventilation modes, because one can connect a separate fresh gas flow on the low-pressure inlet (usually, the high-pressure inlet is used), having the “overflow” of gases go out through the evacuation outlet. This has been a good solution, but there is the question of spare parts, which will be available for another 1 or 2 years, not more. The question of quality ventilation has to do with modes and precision of volume and pressure delivery. In pediatric anesthesia, Jackson-Reeves and other non-rebreathing systems work well. However, most anesthesia systems today are based on circle systems with re-breathing; most have solutions via outlets where one can connect Baines or Jackson-Rees. But this doesn’t solve anything! Why? It is only a solution during induction of anesthesia with inhalation gases. It offers no solutions under the maintenance phase, where it happens that we are forced to hand-ventilate our patient. One uses completely other pressures in hand ventilation than with an anesthesia ventilator; however, should you measure this pressure with a manometer, one would nevertheless be well above values one would be willing to condone if it were being delivered by the ventilator! Hand ventilation is used during the aforementioned ductus repairs, and
Double-lumen tubes are usually used in the small pre-term baby population. Ventilation can be a probing challenge when trying to perform one-lung special surgical procedures. Professor Lönnqvist: What problems are you confronted with on a daily basis?

Professor Lönnqvist: Our daily concerns in pediatric anesthesia often have to do with dead space volumes, due to bacterial filters, humidifiers and other additions, as well as with how to compensate compressible volumes in the machine. This latter problem can be solved by measuring the inspiratory and expiratory O₂ and CO₂, as well as working with pressure-volume loops. The limitation of working with these loops is, however, that one measures pressures inside the breathing circuit and not inside the patient. One can look at the difference between these pressures by inserting a catheter into the trachea, this has been done, and one would see how enormous these differences are! In bigger patients, these differences are much smaller.

Professor Lönnqvist: What problems can you be confronted with during certain special surgical procedures?

Professor Lönnqvist: One-lung ventilation can be a probing challenge in the small pre-term baby population. Double-lumen tubes are usually used in older children and adults for this procedure, however, this solution does not exist for tiny babies. Catheters with a balloon to be blown up in the non-ventilated lung are used in this case, but these can move, allowing unwanted air into that lung, or even obstructing the airways entirely. Proper ventilation during endoscopic surgery of esophageal atresia is also very challenging.

Maquet has conducted a survey about anesthesia segments. They divided up the anesthetic acts into Routine, Complex and Complex Advanced. What are your thoughts about this?

Professor Lönnqvist: If you have a tiny patient and a complex procedure, this will entail anesthetic care which becomes complex advanced, for sure. If one has a very ill patient to treat, it is clear that even a so-called “routine” procedure will become extremely complex. The other aspect has to do with the development of older and older patients who are sicker than before, with less possibilities in their organ systems. This means that the “Complex” group will increase and even “overflow” into the “Complex Advanced” group. These are reasonable concepts. I guess we refer to general anesthesia; regional anesthesia patients belong to an entirely different group.

What functionalities would you like to see on anesthesia systems in the future?

Professor Lönnqvist: As I mentioned previously, it would be ideal if systems in general could address the tiny pre-term 500 gr baby. Otherwise, other gases such as helium and why not, xenon, could possibly have interesting applications. Even carbon monoxide in low doses, it is thought, could be of interest. Some studies have been done on small animals with a gas called “H₂S” (hydrogen sulphide) that have shown some very interesting results; how does it work? It blocks the mitochondria in the cell and causes it to diminish oxygen consumption, CO₂ production, as well as body temperature, making them go into hibernation, or “suspended animation” But in earlier phases of studies where nitric oxide blockers were administered to sepsis patients, one saw beneficial effects on low blood pressure by raising it, while causing interference with the immune response. Many of these patients died. This is an example to illustrate how important it is to have high respect for the different phases of research before administering medication or therapies to humans. Potency goes hand in hand with potent side-effects. Toxicity results in animals must be conclusive before one can conduct trials in humans. But these are, perhaps, “Star Trek” considerations.

Biography

Xavier Capdevila, MD, PhD
Anesthesiologist and Intensivist, as well as University Professor, Dr Capdevila has been working at the University Hospital of Montpellier in France (CHU) where he has been Head of the Department of Anesthesia and Intensive Care since 2001. On an institutional level, he is President of the Anesthetic Pole of the CHU, as well as President of the Scientific Committee of the SFAR (Societe Francaise d’Anesthesie et Reanimation/French Association of Anesthesia and Intensive Care).

Dr Capdevila published a Science thesis in the Physiology of Respiration “Implications of Prolonged mechanical ventilation on respiratory muscles impairment and patient’s weaning from ventilator” and has worked both in the fields of intensive care and anesthesia, but became very interested in anesthesia about ten years ago. He began first by himself, then in collaboration with his colleague, Samir Jaber, MD, PhD, to look into the care of the patient in anesthesia from the points of view of the mechanics of respiration, ventilatory control and the optimization of ventilatory possibilities provided by these patients.

Xavier Capdevila has conducted and published extensive scientific research in the field of ventilatory mechanics in anesthesia.

Per-Arne Lönnqvist, MD, PhD
Anesthesiologist and Intensivist since 1987, as well as Sweden’s only Professor in Pediatric Anesthesiology (since September 2007), Dr Lönnqvist works as a pediatric anesthesiologist at Astrid Lindgren Children’s Hospital.

Dr Lönnqvist has also spent a year at Portland’s University Hospital, in Portland, Oregon, where he worked with both pediatric and adult anesthesia. He has been very active in scientific research in ventilation mechanics, as well as the use of nitric oxide, among other aspects.
FLOW-i in clinical use for the first time: First Impressions given by five clinicians

MAQUET’s FLOW-i Anesthesia system, after having been launched in 11 European countries, was sent in April to five hospitals in Europe, one in Sweden, one in Belgium, one in Germany and two in Italy, for validation sessions.

Over 300 patients were put to sleep with FLOW-i over a span of 4 weeks, and the overall impression of the performance and capacities of the system were positive.

Critical Care News visited three of the five validation sites in order to speak to the clinicians who had tried FLOW-i. The questions centered around the ages of the patients put to sleep, the average length of the procedures, particular aspects related to their daily practice, as well as machine related questions; the clinicians we interviewed had things to say about the anesthesia system’s ergonomy, its ease of use, as well as its ventilatory performance.

The following pages takes you to these sites where Critical Care News was able to obtain first impressions of clinical use.
Critical Care News met Professor Iapichino, Dr Assi and Dr Di Mauro, of the Department of Anesthesia and Intensive Care of the San Paolo Hospital of Milano. The following is what they had to say.

**About their daily practice**

We have used FLOW-i on both adults (80% of cases) and children (20% of cases), with procedures lasting between 20 minutes and 7 hours. The same clinician used FLOW-i at least twice, for an average of 8 hours. The eldest patient was 85 years old, the youngest was less than a year old.

**First impressions of FLOW-i**

It is surprisingly easy to use, if compared to similar electronically driven workstations. Even the most traditional anesthesiologists on staff were comfortable using it. We liked the ergonomics, with the height-adjustability which we used during lengthy procedures, as well as the ease of the User interface, with its loop freezes which are nice especially during lung surgery. The patient “picture” is more complete, it is easy to use. The condensation in the patient cassette is much lower than we expected, and although the absorber canister is smaller then in other systems, it lasted longer.

Our nurses liked that the breathing circuit was easy to disassemble before cleaning, with no small parts. Although the pre-use check is a bit longer, it is easy to perform and all settings are easy to find. We would like to have PRVC and SIMV among the future modes of ventilation. Concerning the ventilatory performance, it was very good on all patient categories; the leakage detection is very precise and quick; and the flow Trigger is very sensitive. Overall a very positive impression…..
ZNA Middelheim is the largest hospital of the Antwerp Hospital Network in Antwerp, Belgium. Dr Dirk Himpe had the following comments.

**About their daily practice**

We have had predominantly adult patients and some as young as 15-16 years of age. The shortest case we did with FLOW-i was about 30 minutes, the longest one was about 12 hours long, but on average the procedures lasted one hour.

**First impressions of FLOW-i**

I find FLOW-i to be a very interesting machine with its ergonomic features; we have actually tested the possibility of working from different positions, more specifically, after rotating the swivel-arm and turning the control panel and hemodynamic monitor towards the back side of the machine, when doing maxillo-facial surgery. I also liked the height-adjustability, which I used at the end of a day’s work for comfort. It was a positive experience. The ventilatory performance has been really very good in the cases that we have done, although we did not have the chance to do one-lung ventilation, which would have tested the ventilator to its limits, as this case was unexpectedly cancelled. The agent setting is done differently from what we are used to, with a touch of the screen and the rotary knob, but it is just a question of getting used to it. I would like to see the information about gas consumption on the screen, as there are environmental and economical reasons for this. Perhaps a few more respiratory mechanics, as well as metabolics would be nice.
Critical Care News met with Dr Gallioli, MD, from Vimercate Hospital in Monza, Italy. The following is what he had to say about his first impressions of FLOW-i.

**About their daily practice**

Most of the procedures done with FLOW-i were on adult patients, with the exception of a 3 year old. The eldest patient was 85 years old. The average length of the procedures varied between 1.5 hours to a maximum of 4 hours. Every anesthesiologist on our staff was able to use FLOW-i for at least 4 hours.

**First impressions of FLOW-i**

FLOW-i has premium performances and is very easy to use. It performed very well on all our patients; we did 50 cases overall. We appreciated the User Interface which we found very clear, well organized and user friendly, without any “hidden” menus. It was easy to use even after our first attempt. The height-adjustability was a nice feature, which we used to adapt the height to the staff. Regarding FLOW-i’s ventilatory performance, we found it was excellent; we even used it to perform one-lung ventilation during a pulmonary surgery case.
ESA Maquet Anesthesia Research Award

The European Society of Anesthesiology and Maquet Critical Care are pleased to announce a new research award in anesthesiology.

Our aim is to support research in a certain focus area every year which may be of importance for perioperative ventilation during complicated anesthetic procedures. Examples of complicated anesthetic procedures include pediatric anesthesia, thoracic anesthesia, anesthesia for the obese, or anesthesia for critically ill patients with acute respiratory failure.

The area of interest for 2011 covers research projects concerning respiratory muscle function during and after anesthesia.

The research plan of highest interest and importance will be rewarded with 10000€. Researchers of younger age and innovative ideas will be prioritized.

Short guidelines

1. Only members of ESA are invited to submit an application.
2. The research can be either basic concept studies or clinical studies in humans and an application of maximum 4 pages (double-spaced A4) should include:
   - Short introduction
   - Study design with objectives, hypothesis and endpoints
   - Data collection and planned analysis
   - Safety parameters when applicable
   - Key references
3. The deadline for application will be 1st of March 2011.

The research plans will be evaluated and prioritized by the ESA Research Committee.

In the year the grant is awarded, the winner will receive free registration to the ESA Congress to accept the prize during the awards ceremony.

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