ICU MANAGEMENT

THE OFFICIAL MANAGEMENT AND PRACTICE JOURNAL

VOLUME 11 - ISSUE 1 - SPRING 2011

THE AIRWAY

PLUS:

- Utilising CT Scans for ARDS
- How Should We Control Blood Glucose in 2011?
- New Developments in Renal Replacement Therapy (RRT)
- Interview with Derek C. Angus: Striking the Perfect Work / Life Balance

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THE AIRWAY

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We are delighted to once again welcome you to the International Symposium on Intensive Care and Emergency Medicine in Brussels, Belgium. As our 31st, I am reminded that every year that passes marks another step forward in our evolution as a field.

As patients in the intensive care unit often require support for airway and respiratory compromise, it is fitting that not only does this issue of ICU Management centre on THE AIRWAY, but our meeting also coincides with World TB Day 2011, which falls on March 24th each year. This date commemorates the day in 1882 when Dr. Robert Koch astounded the scientific community by announcing that he had discovered the cause of tuberculosis, the TB bacillus. When Koch made his momentous announcement in Berlin, TB was raging through Europe and the Americas, causing the death of one out of every seven people. Koch's discovery opened the door towards diagnosing and curing TB.

Of course, in much of the (mainly developing) world, tuberculosis remains an epidemic today, causing the deaths of several million people each year. Increased awareness and progress in rapid diagnostic testing, which can be implemented in low resource settings are encouraging steps forward in this continued fight against TB internationally.

In this issue on The Airway, we feature articles on Protocolised Versus Non-protocolised Weaning from Mechanical Ventilation in Adult Critical Care (Dr. Lavery and Prof. Blackwood; Belfast, N. Ireland); The Importance of Oral Care in Reducing VAP in Mechanically Ventilated Patients (Nancy Njoroge and Fiona Paul; Edinburgh, Scotland) and

Drs. de Abreu, Rocco and Pelosi discuss utilising CT scans in defining ARDS and guiding possible therapeutic strategies.

Within the Matrix features you will find articles on The Changing Face of Abdominal Compartment Syndrome (authored by Drs. Smith and Cheatham from Orlando, USA); an Update on Glucose Control in 2011 (from Dr. Preiser and myself) and Drs. Joannes-Boyau and Honoré inform us about New Developments in Renal Replacement Therapy (RRT).

Bridging the Gap Between Theory and Practice is the topic discussed by Dr. Blot and colleagues from Ghent, Belgium in our Management section and there is an interesting interview in our Viewpoints section with world-renowned researcher and management guru Dr. Derek Angus (Pittsburgh, USA).

Everyday we make simple discoveries; find easier and more effective methods to treat our patients and network with our collaborators at meetings like ISICEM – Sharing information and resources, which open doors to more discoveries and treatments. Koch's monumental breakthrough may have paved the way for the future eradication of a deadly epidemic, but it should not overshadow the clinical and research based progress we are making against other conditions like sepsis.

I hope that you take this opportunity to consider how you and the other members of your teams in institutions around your part of the world are opening doors and moving the fields of intensive care and emergency medicine forward for the generations to follow.

Jean-Louis Vincent

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ICU Management

is the Official Management and Practice Journal of the International Symposium on Intensive Care and Emergency Medicine and was previously published as Hospital Critical Care.

RESEARCH NEWS

Hospital Infections and Multidrug-Resistant Pathogens

Infections are among the most frequent complications of a stay in hospital and raise the complication and mortality rates. Calculations based on data from the Hospital Infection Surveillance System (Krankenhaus-Infektions-Surveillance-System, KISS) showed an incidence of almost 60,000 newly acquired infections per year in intensive care units in Germany. This is the conclusion reached by Christine Geffers and her coauthor in the current issue of Deutsches Ärzteblatt International. KISS is a quality assurance tool for hospitals. More than 800 hospitals and 586 intensive care units throughout Germany are enrolled with KISS.

While the percentage of patients in intensive care who have methicillin-resistant Staphylococcus aureus species (MRSA) has been steady for years, the number with extended-spectrum beta-lactamase (ESBL)-producing Escherichia coli and Klebsiella pneumoniae is rising. In hospital, the risk of acquiring Clostridium difficile-associated diarrhea is higher than the risk of acquiring MRSA.

The above story is reprinted (with editorial adaptations by ScienceDaily staff) from materials provided by Deutsches Aerzteblatt International, via AlphaGalileo.

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Journal Reference:
Geffers Chr, Gastmeier P. Nosocomial infections and multidrug resistance organisms – epidemiological data from KISS. Dtsch Arztebl Int, 2011; 108(6): 87%u201393

EU NEWS

eHealth Moves Ahead in Europe: Reports on eHealth Strategies and Implementations in 30 Countries in Europe Now Available

Since the publication of the European Commission's (EC) eHealth Action Plan in 2004, eHealth has gained significant momentum across Europe. "European countries on their journey towards national eHealth infrastructures - evidence of progress and recommendations for cooperative actions" is the title of a just released overview and synthesis report on eHealth in Europe. The EC sponsored eHealth Strategies study has pre-published an online version of this report, which is available at the study website.

In addition, more than 30 individual reports detailing policy actions and deployment of eHealth applications in Member States and other European countries are available there as well.

The summary report traces European countries' progress along the goals set out in the eHealth Action Plan. It focuses on the core applications of EHR-like/patient summary and ePrescription systems. It also analyses governance, structural and legal issues as well as policy lifecycle aspects.

Study results show that in virtually all European countries surveyed, political as well as stakeholder interest in eHealth policies, and the planning and implementation of national or regional infrastructures has gained great momentum. This concerns not so much the number of new priority objectives identified, infrastructure elements tackled or pilots run, but rather the overall level of awareness, activities and concrete undertakings.

A host of experts as well as reviewers from the i2010 Subgroup on eHealth contributed their intimate knowledge of the eHealth situation in their respective countries and validated the content of the country reports. This comprehensive collection of country information constitutes a unique resource and important database of up to date evidence on eHealth progress across Europe, which updates and complements the results of the earlier eHealth ERA study of 2007.

www.ehealth-strategies.eu

BOOKS IN REVIEW

Core Topics in Airway Management

Authors: Ian Calder and Adrian Pearce / *Cambridge University Press; 2nd Edition (2011)*

Every anaesthetist reaches the end of their career with a collection of difficult airway experiences. Managing airway challenges relies on a combination of good clinical practice, knowledge of relevant basic sciences and critical evaluation of every aspect of airway care. This new edition of Core Topics in Airway Management provides any trainee or consultant involved in airway techniques with practical, clinically relevant coverage of the core skills and knowledge required to manage airways in a wide variety of patients and clinical settings. All new procedures and equipment are reviewed, and detailed chapters advise on airway issues in a range of surgical procedures. This edition also contains a series of practical questions and answers, enabling the reader to evaluate their knowledge. Written by leading airway experts with decades of experience managing difficult airways, Core Topics in Airway Management, second edition, is an invaluable tool for anaesthetists, intensivists, and emergency physicians.

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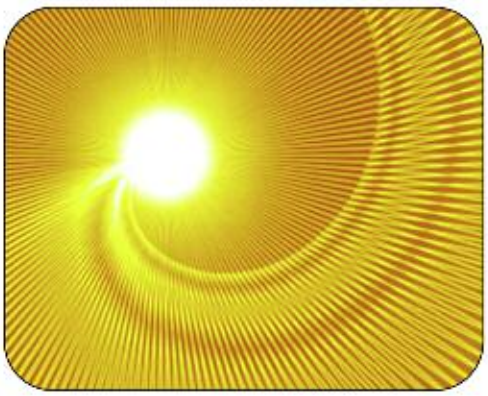

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PROTOCOLISED VERSUS NON-PROTOCOLISED WEANING FROM MECHANICAL VENTILATION IN ADULT CRITICAL CARE

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Although mechanical ventilation (MV) provides physiological benefit during critical illness, it may also predispose to respiratory infection, lung injury, cardiovascular instability, limited communication, the need for sedation, and delirium. Reduction and discontinuation of ventilatory support (a process termed weaning) as soon as the patient can sustain spontaneous breathing, is an important goal in critical care. Patients in whom weaning is difficult or prolonged have higher rates of mortality (Mancebo 1996), ventilator-associated pneumonia (Vincent et al. 1995), and lung injury. Timely and safe cessation of ventilation facilitates desirable outcomes for patients, clinicians and the healthcare system.

In the UK, weaning is usually a collaborative task. Nurses use general guidance from medical staff to advance or delay weaning according to the patient's response. Often there are no specific (written) criteria to determine the best time to start weaning and no formal guidelines for reducing support. Nurses' engagement in weaning may be influenced by experience, personal preference or the ICU culture. The overall result is wide variability in weaning practices.

Deciding when and how to wean a patient is influenced by the judgment and experience of the doctor. Predictions, based on judgment alone, have low sensitivity and specificity – the ability to predict success and failure. Until recently, there have been few weaning standards based on sound data and so a wide variation exists in weaning practice. Weaning methods include:

- Intermittent T-piece trials,
- Reduction of synchronised intermittent mandatory ventilation or pressure support ventilation, and
- Spontaneous breathing through a ventilator circuit with reducing continuous positive airway pressure.

Combinations of these and newer modes, such as bi-level, positive airway pressure are also used. There is little evidence of superiority for any of these methods, although synchronised intermittent mechanical ventilation may be least effective.

What is a Weaning Protocol?

There is increasing interest in promoting more consistent weaning practices within ICU by developing protocols providing structured guidance. Protocols should improve efficiency of practice by using expert consensus to reduce variation produced by the application of individual judgment and experience. They typically have up to 3 components (Figure 1).

While most weaning protocols or guidance used in ICUs are written, advances in microprocessor technology have enabled development of computer-assisted management of ventilation and weaning. These systems measure and interpret respiratory data in real time and provide continual adjustment of the level of assistance within targeted values. By enabling 'interaction' between the patient and the ventilator, such closed loop systems may improve tolerance of ventilation and reduce work of breathing (Burns et al. 2008). Several commercial computerised ventilation and weaning programmes have been developed, including adaptive support ventilation, proportional assist ventilation and pressure support ventilation (Rose et al. 2007) [SmartCare].

Evidence from the Literature

There is evidence suggesting that weaning protocol use improves outcomes, and/or reduces the duration of ventilation (Marelich et al. 2000; Strickland Jr and Hasson 1993). From 2000 to 2003, two of the largest general adult Intensive Care Units (ICU) in our region collaborated in a study of protocolised weaning from mechanical ventilation, the first in the UK to use a prospective, controlled comparison of the effectiveness of weaning protocols on patient outcomes (Blackwood et al. 2006). The study found that admission APACHE II score and diagnostic category were significant predictors for MV time, intubation time and ICU stay, but the use of protocolised weaning was not - findings that failed to support

previous studies. There are several potential reasons for such disagreement.

It has been reported that patients who successfully complete a spontaneous breathing trial (SBT) can be extubated two hours after determining their ability to wean rather than having a stepwise reduction in ventilatory support (Ely 2001). Studies incorporating daily assessments of readiness to wean and SBTs in their protocols demonstrated significant reductions in MV time (Marelich et al. 2000; Grap et al. 2003; Saura et al. 1996). Our weaning protocols did not incorporate an SBT due to lack of ICU consultant agreement (Blackwood et al. 2004). Reasons included the perceived need to maintain control of weaning in a widely variable group of patients and unease about protocols being applied by inexperienced staff.

Randomised controlled trials which have shown significant reductions in MV times (Marelich et al. 2000) based their intervention on structured protocols versus "no weaning unless directed" - a bipolar manipulation representing two extremes of a continuum which makes detection of differences more likely. This type of manipulation is clearly suited to ICUs where patients are managed by 'attendings' and where nurses do not progress weaning without a medical order. In contrast, in our units (as in most of the UK) there is closer collaboration on weaning between the 'on-site' ICU consultants/doctors-in-training and nurses. Some nurses are proactive in reducing ventilatory support. In most UK ICUs, there is frequent medical review during the day. This was 'usual practice' for both ICUs in our study. These factors may have resulted in the manipulation being less bipolar than in studies suggesting protocolised weaning reduced weaning time or time on MV.

Finally, the intervention guidelines dictated that having determined patients' readiness to wean using a daily screening tool, nurses had to obtain agreement from the duty consultant before proceeding to wean. Hence, it is possible that, at times, usual practice (experienced nurses autonomously reducing support) may have been inhibited by the constraints of the protocol.

> **"Thus, the nature of the (weaning) intervention, the pre-existing ICU culture and how the intervention "fits" into existing practices may all be important influences on the success (or failure) of protocolised weaning."**

Thus, the nature of the (weaning) intervention, the pre-existing ICU culture and how the intervention "fits" into existing practices may all be important influences on the success (or failure) of protocolised weaning.

A recent systematic review assessed evidence from randomised and quasi-randomised controlled trials comparing protocolised versus non-protocolised weaning on the duration of MV (via a nasotracheal or orotracheal tube) in critically ill adults (Blackwood et al. 2010; Blackwood et al. 2011). From a total of 6,016 citations retrieved from electronic databases, 14 trials were reviewed in full and further information was obtained on seven unpublished trials. 11 trials, involving 1,971 patients met the inclusion criteria.

In these 11 trials, protocolised weaning led to statistically significant reductions in geometric mean values; 25% for the total duration of mechanical ventilation; 78% for weaning duration, and 10% for ICU LOS. Data from a large epidemiological study (N = 5183) of characteristics and outcomes in patients receiving mechanical ventilation (Esteban et al. 2002) showed a mean value for the risk of duration of mechanical ventilation of 144 hours. Applying the effect estimates in the systematic review to these data, protocolised weaning would reduce the assumed risk for:

- total duration of mechanical ventilation from 144 hours to 108 hours (95% CI 87.8 - 131 hours);
- weaning duration from 96 hours to 21 hours (95% CI 6.7 - 66.2 hours);
- and ICU LOS from 11.2 days to 10.1 days (95% CI 9.07 - 10.97 days).

Whilst the above appears to support a benefit from protocolised weaning, the review authors were cautious in their conclusions. While the included trials were methodologically sound and had a low risk of bias based on GRADE (Guyatt et al. 2008), the quality

1. Readiness to Wean Criteria:

General clinical factors which help decide if a patient is ready to begin breathing without the help of a ventilator (Ely et al. 1996)

2. Structured Guidelines for Reducing Ventilatory Support:

Abrupt - Spontaneous Breathing Trials (SBT)
Gradual - Stepwise reduction in support (Brochard 1994; Esteban 1995; Kollef 1997; Marelich 2000).

3. Readiness for extubation criteria* – (Hendrix 2006).

*Optional - Extubation is not strictly part of weaning but is often the ultimate goal following successful weaning

Figure 1. Elements of a weaning protocol

of evidence was low; mainly due to the significant heterogeneity among the included studies, particularly in relation to total duration of MV (I2 = 58%), and weaning duration (I2 = 97%). Trial methodology was limited by the inability to blind clinical staff to the method of weaning, potentially leading to biased estimates of treatment effect. However, following assessment of the blinding of those collecting outcome data, the risk of bias was viewed as low in eight out of 11 included studies. Six of 11 studies originated in the US, potentially limiting the applicability or relevance of the findings to other healthcare systems.

The use of weaning protocols did not adversely impact on ICU or hospital mortality. Protocol use did not appear to increase the frequency of adverse events including reintubation, self-extubation, tracheostomy and protracted weaning. However, the meta-analysis was underpowered to investigate the impact of the interventions on these infrequent outcomes.

Clinical Implications

Ventilator weaning is a complex process. The discordance in results among studies may be due to contextual factors (differences in patient populations and usual practice within units) or intervention factors (differences in determining readiness to wean; ventilator modes and parameters used in weaning protocols). Clearly, weaning a surgical ICU patient following elective major surgery is often a more straightforward process than weaning a medical ICU patient with respiratory failure due to acute exacerbation of chronic pulmonary disease.

Another important contextual factor is the use of the 'usual care' group as a control in randomised trials (Thompson and Schoenfeld, 2007). Usual care in ICUs may encompass a wide variety of practices. It may be based on high-level evidence, representing best practice, or it may be highly variable, including unfavourable practices. If usual care in an ICU involves a consistent high quality approach to weaning, albeit not formally laid out in guidelines, then it may not differ greatly from that delivered by a weaning protocol. The study by Marelich et al. (2000) was conducted in two ICUs with differing weaning practice and found that the surgical ICU, but not the medical ICU, had a standardised approach to weaning. While combined data demonstrated protocol use decreased the duration of MV, unit data, analysed separately, showed a statistically significant reduction only in the medical ICU (where no previous standard approach to weaning existed). Similarly, Rose et al. (2008) attributed their lack of effect to the usual practice in their ICU: Unlimited assessment of weaning by experienced autonomous nurses; a 1:1 nurse to patient ratio supported by 24-hour medical staff and twice-daily intensivist rounds.

Conclusion

Protocolised weaning may decrease total duration of MV, weaning and ICU length of stay due to consistent application of objective criteria for determining readiness to wean and a guided approach to reducing support. Reduced duration of MV may lead, in turn, to reduced requirements for tracheostomy. However, in settings where objective criteria and guided approaches are already incorporated into standard weaning practice, the beneficial effects of protocolised weaning on the above may not be realised. ■

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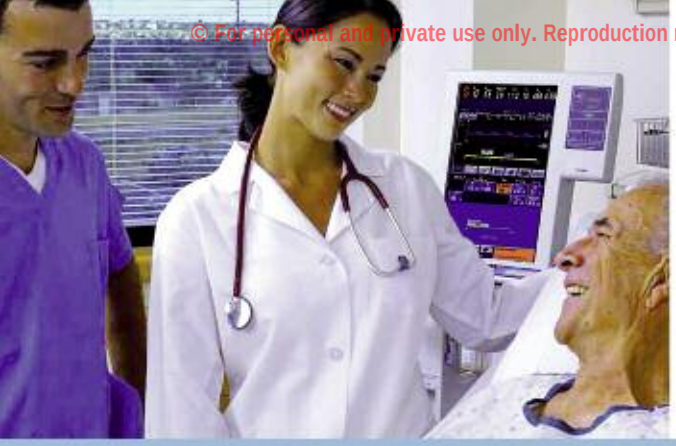

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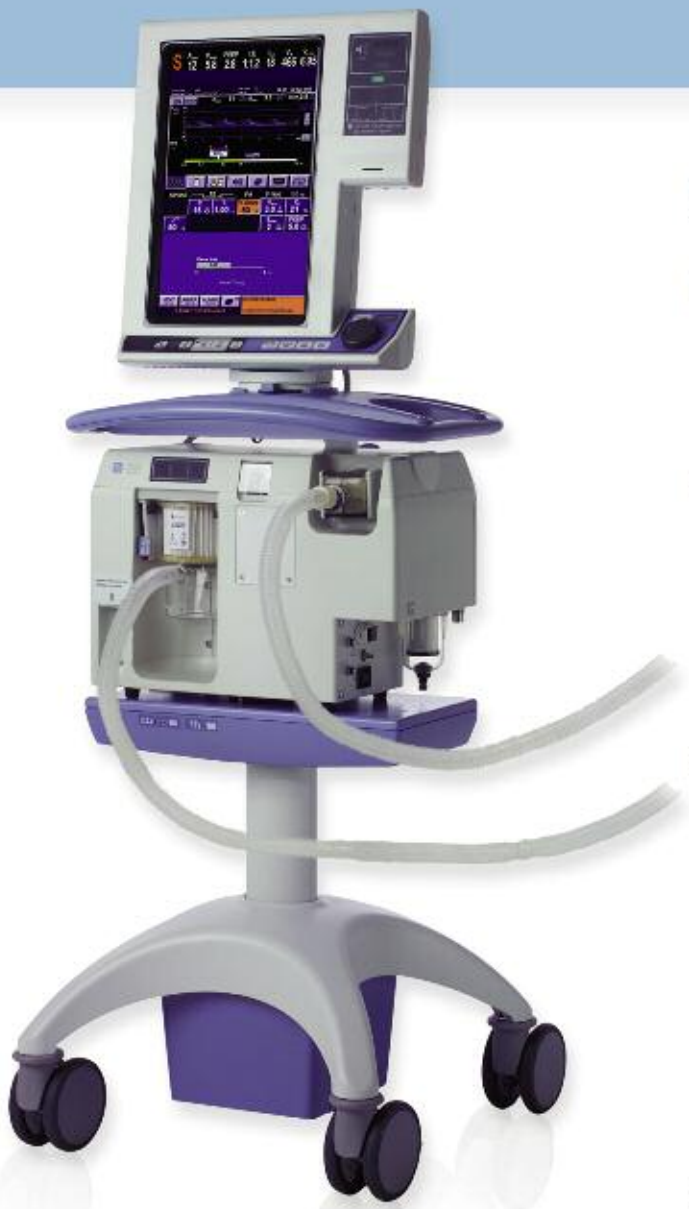

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REDUCING VENTILATOR ASSOCIATED PNEUMONIA (VAP): THE IMPORTANCE OF ORAL CARE IN MECHANICALLY VENTILATED PATIENTS

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The role of oral hygiene in maintaining the health and wellbeing of mechanically ventilated patients in intensive care is evident. Patients in intensive care have complicated needs and poor oral hygiene may result in nosocomial- acquired infections such as pneumonia. Nevertheless, the importance of mouth care is not often reflected in ICU literature and practice (Prendergast et al. 2009). To date, there is no definitive protocol (Grap and Munro 2004) to guide healthcare providers in the most appropriate methods of oral care.

The aim of this article is to identify the importance of and barriers to effective oral hygiene, as well as the implications of poor oral health and the most recommended methods of providing oral care in mechanically ventilated patients.

Introduction

Evidence shows that patients can become colonised with pathogenic bacteria within forty-eighty hours of admission to intensive care unit. The oral cavity and its components especially dental plaque are perfect media in which bacteria can colonise (Prendergast et al. 2009). In addition, aspiration of orapharyngeal secretions is an independent risk factor for ventilator associated pneumonia (VAP) and is recognised as being a major cause of the acquisition of nosocomial infection in the ICU (Berry et al. 2007). However, some patients have oral health problems before admission to intensive care unit.

VAP is defined as pneumonia that develops in an intubated patient after forty-eight hours or more of mechanical ventilation (Kishmoto and Urade 2010). VAP is the second most common nosocomial infection, but it is the leading cause of death in ventilated ICU patients.

Key proposed practices in the prevention of VAP include:

- Semi-recumbent patient positioning;
- Selective digestive tract decontamination;
- Subglottal suctioning; and
- Dental plaque colonisation with respiratory pathogens reduction.

As most of the proposals above are fundamental nursing practices, it is clear that nurses themselves play a critical role in minimising VAP. However, in the current ICU environment, emphasis on oral health is often lacking in mechanically ventilated patients despite the fact that the literature shows that these patients are at the highest risk for the second most common nosocomial infection, pneumonia (Berry et al. 2007). In fact, (VAP) is the second most common nosocomial infection, but is the leading cause of death (Munro et al. 2009).

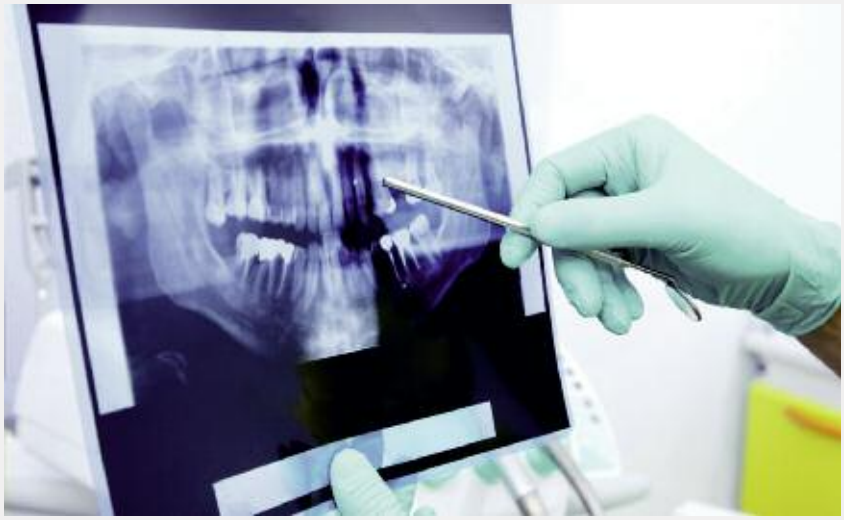
Aside from the staggering mortality rates, VAP also has a drastic affect on cost-effectiveness. Patients who develop VAP have a higher number of days on mechanical ventilation, a longer length of stay in intensive care and a doubling of the overall hospital stay. Oral care in mechanically ventilated patients has been identified as one of the preventative measures against acquiring ventilator associated pneumonia.

Risk factors affected by oral and dental care are:

- Bacterial colonisation of the oropharygeal area; and
- Aspiration of subglottal secretions and colonisation of dental plaque with respiratory pathogens.

Therefore, implementation of a comprehensive oral care procedure may decrease the risk of acquiring VAP. However, McNeill (2000) argues that providing adequate oral hygiene for patients in ICU is particularly challenging, not least because of the problems of caring for very sick patients in a busy stressful environment, which may result in oral care having a lower priority for nurses than other aspects of care. In addition, Pearson and Hutton (2002) add that maintaining a healthy oral environment in an ICU patient can be problematic due to the presenting condition of the patient and the medical treatment provided. Many

ICU patients are immune-compromised as well as have a predisposition to oral infections such as herpes simplex. On the other hand, Kishmoto and Urade (2010) and Berry et al. (2007) have demonstrated that bacteria responsible for VAP colonise on the oral mucosa and in the dental plaque of intubated patients; consequently providing adequate oral care should be a priority as it is very important in reducing incidences of VAP.



Challenges

There are a number of simple challenges nurses encounter in their attempt to provide proper oral care: Inadequate tools (e.g. a normal sized adult toothbrush is often difficult to manoeuvre around all the obstacles in the patients' mouth such as endotracheal tube (ETT), tapes, oral gastric tube and a temperature probe) and simple logistics (e.g. the posterior area of the patient's mouth is rarely reached)

Standard toothbrushes cannot be used in patients who have bleeding gums and / or low platelets counts and extreme care should be taken when providing oral care for these patients, regardless of the tool used (Ruffell et al. 2008). It is advisable to use soft-bristled 'baby' toothbrushes, which not only provide greater access to all regions of the mouth but can also be used to cleanse patients tongues and gums.

There are various assessment tools available to assess patients mouths, but these assessment tools are not often used in practice due to lack of time or knowledge or because they fail to assist nurses in diagnosing oral problems (Abidia 2007; McNeill 2000). Collaborative interactions with dental hygienists could improve the nurses' knowledge and skill related to oral care, however, dental hygienists are not routinely employed in care of ICU patients to advise nursing staff (Abidia 2007). Additionally, studies on oral care methods in ICU have found that nurses do not use evidence based oral care methods in practice (Berry et al. 2007).

Toothbrushes vs. Foam Sticks

Many nurses are reluctant to use toothbrushes with toothpaste for cleaning the teeth of intubated patients, preferring instead to use foam sticks. However, the foam stick is not as effective in plaque removal as a soft, small-headed toothbrush (Prendergast et al. 2009; Rawlins 2001). However, when toothbrushes are not available, foam sticks soaked in chlorhexidine mouthwash may be a useful alternative to toothbrushes. Chlorhexidine is effective against gram-positive and gram-negative bacteria as well as fungi and yeast (Pineda et al. 2006). A controlled trial of 34 patients that compared the ability of foam swabs versus toothbrushes to remove dental plaque concluded that tooth brushing was preferred and should be taught to nurses and clinical support workers (Pearson and Hutton 2002). Other randomised controlled trials advocate the use of chlorhexidine mouthwash and gel in mechanically ventilated patients as it significantly reduces the incidence of nosocomial respirato-

ry infections and pneumonia (Grap and Munro 2004). These studies also showed that this should be done after teeth brushing since it is more effective way of removing dental plaque.

> "...patients who develop VAP can have as high as a seven-fold increase in the number of days on mechanical ventilation, a two to five-fold increase in the length of stay in intensive care and a doubling of the overall hospital stay."

Emphasis on the provision of mouth care is allocated a low priority in a number of nursing undergraduate programmes, and although it is considered basic nursing care, it is often a low priority when caring for a complex intensive care patient (Longhurst 1998). There is a lack of oral health knowledge and lack of appreciation of its importance by registered nurses, and the length of ICU experience does not correlate to the quality of oral care provided by nurses. To compound this deficit in knowledge, there is a lack of standardised protocols based on empirical evidence for mouth hygiene in ICU. Therefore, lack of evidence based guidelines to direct practice allows critical care nurses to perform oral hygiene according to their individual preferences (Moss 2004). Consequently, if a change in practice, supported by best evidence is to be accomplished, it is crucial that this evidence is adapted to the individual healthcare environment and one has a clear understanding of what evidence based practice means (Cook 2003; Grap 2003).

There is also a need for ICU clinicians to develop guidelines to inform practice and more education is required to stress the importance of oral care in intubated patients. Lastly, guidelines should be evaluated for their effect, value and usage, and reviewed and modified regularly to incorporate new evidence (Courtney 2005). By incorporating a comprehensive oral care protocol into the unit's current VAP reduction bundle practices, patients' lives can be optimised and financial resources can be saved.

Multiple methods exist to provide oral care however there is no clear consensus on how frequently mouth hygiene should be performed.

Recommendations

- Oral care should be considered as part of the admission assessment in intensive care units. This should include assessing patients' oral cavity on admission as well as daily assessment of the lips, oral tissue, tongue, teeth and saliva of each patient. The initial assessment would allow identification of oral hygiene problems and for continued observation of oral health.
- Development of oral health protocols in intensive care units and staff education are very important. Additionally, the importance of oral care should be

B - BLEEDING	Gums, mucosa, coagulation status?
R – REDNESS	Gum margins, tongue? Antibiotic stomatitis?
U - ULCERATION	Size, shape, herpetic? Infected?
S – SALIVA	Xerostomia, hypersalivation characteristics?
H – HALITOSIS	Character, Acidotic? Infected
E – EXTERNAL FACTORS	Angular chelitis? Endotracheal tapes?
D – DEBRIS	Visible plaque? Foreign particles

Table 1. Brushed Assessment Model Adapted from Hayes and Jones (1995)

MUCOUS MEMBRANES/GUMS
0= Pink and moist with firm gums
1= Reddened/Oedema/Radiation plaque
2= Ulceration/Bleeding

COMFORT
0= Comfortable
1= Discomfort
2= Pain

LIPS/CORNER OF MOUTH
0= Smooth, pink, moist
1= Dry cracked
2= Ulcerated/ bleeding
3= Herpes simplex

CANDIDA/INFECTION
0= No
1= Yes

TONGUE
0= Pink and moist
2= Coated
3= Blistered/cracked

TEETH/DENTURES
0= Clean, no debris
1= Loose teeth/ ill fitting dentures
2= Debris
3= Caries

SALIVA/DRY MOUTH
0= Watery
1= Thick or ropey
2= Absent/Dry mouth

SWALLOW/CHEWING
0= Normal
1= Unable to swallow/chew normal diet
2= Unable to swallow soft diet
3= Unable to swallow fluids
4= Unable to swallow saliva
SCORE= 0- Follow standard mouth care protocol + specific intervention for a healthy mouth
SCORE↗ 0- Follow standard mouth care protocol + refer to specific intervention and individual interventions

Table 2. Daily oral care health assessment form Adapted from Pear et al. 2007

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[1] 354 product evaluations from 27 hospitals in US were completed by nurses and respiratory therapists

emphasised in nurse education programmes, along with training for healthcare assistants who may be delegated to provide oral hygiene in some areas. Although frequency of oral care remains an area of controversy and may depend on patient condition, brushing teeth every 12 hours should be recommended and oral moistening should be done at least every two hours and as required while the patient remains intubated. This will assist in the maintenance of healthy lips and gums. In addition, dryness and cracking of oral tissues and lips provide regions for bacteria proliferation. On the other hand, water-soluble moisturiser allows tissue absorption and added hydration.

- Development of standardised, reliable and valid oral assessment techniques and tools for assessing patients, documenting nurses' assessment of oral hygiene interventions, evaluating practice and improving the quality of care are required. Examples of assessment tools available are included in tables 1 and 2.
- Steps should also be taken to increase the awareness of the importance of oral care provisions for mechanically ventilated patients. In addition, oral care packs containing a very small, soft bristled toothbrush and toothpaste should be widely available in intensive care units.
- Finally, the role of specialised oral care medicine services in diagnosing and treating oral diseases in ICU patients is unclear; hence further research is required to determine if nurses in ICU should liaise with oral care medicine services for advice and support when necessary.

> **"Kishmoto and Urade (2010)… have demonstrated that bacteria responsible for VAP colonise on the oral mucosa and in the dental plague of intubated patients; consequently providing adequate oral care should be a priority as it is very important in reducing incidences of VAP."**

Conclusion

Critically ill patients usually have multiple risk factors, which make them prime candidates for the development of VAP. These factors include the patients level of consciousness, oral-pharyngeal or gastric colonisation and dental plaque.

It is clearly evident from the literature that further research is required regarding oral hygiene practices in intensive care, especially in the development of oral care protocols for ventilated patients.

Encouraging the general use of an oral care assessment tool is important and further oral care education to staff working in intensive care is required.

Despite the importance of providing oral care to mechanically ventilated patients in intensive care, high-level evidence from randomised controlled trials and systematic reviews reveal that practice is limited. Hence, there is a clear need for more research to develop guidelines to influence practice and more education is required to stress the importance of oral care in intubated patients. Lastly, guidelines should be evaluated for their effect, value and usage, reviewed and modified regularly to incorporate new evidence that becomes available. ■

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COMPUTED TOMOGRAPHY IN ARDS

Acute Respiratory Distress Syndrome (ARDS) is a generalised inflammation of the lung parenchyma, caused by different underlying diseases. It is characterised by diffuse pulmonary infiltrates, decreased respiratory system compliance and severe hypoxaemia (Ware 2000). Although important advances have occurred in the therapy of ARDS, mortality due to this syndrome remains extremely high (Phua et al. 2009). CT scanning could be useful for defining the pathophysiology of ARDS and guiding possible therapeutic strategies.

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Technical Aspects

Gas/Tissue Ratios

CT scans are able to give insight onto the quantitative relationship between gas and tissue in the lungs. CT scans produce digital images consisting of voxels, i.e., volume elements that attenuate the radiation according to the atomic number of the substance and the density of their contents. The unit of the CT number scale is named Hounsfield Unit (HU). Per convention, distilled water has a CT number of 0 HU, air a value of -1000 HU, and bone +1000 HU. Due to a linear relationship, a voxel with a CT number of -500 HU has 50% of its volume corresponding to gas and 50% to tissue. Assuming that the density of tissue is 1 g/cm^3, the total lung mass can be also calculated using CT scanning.

Aeration Compartments

Voxels, they can be grouped into the

- Hyperaerated (-1000 to -900 HU);
- Normally aerated (-900 to -500 HU);
- Poorly aerated (-500 to -100 HU); and
- Nonaerated compartments (-100 to -100 HU).

The determination of such compartments can be useful to understand and follow the effects of ventilation strategies in ARDS. Figure 1 illustrates the distribution of aeration compartments in a CT scan of a pig at low and high PEEP levels.

Tidal Hyperaeration, Recruitment and Reaeration

In ARDS, tidal hyperaeration, i.e. the increase of the hyperaerated compartment, has been shown to correlate closely with overdistension (Rouby et al. 2003). Accordingly, changes in aeration status of non-aerated and poorly aerated regions may reflect tidal reaeation and/or recruitment in such patients (Gattinoni et al. 2006; Carvalho et al. 2008).

Few Slices or Whole Lung Computed Tomography?

Cumulative exposure to ionising radiation has been associated with increased risk of cancer (Griffey and Sodickson 2009). Thus, investigators have suggested to limit the lung CT scans to only one slice at the base level, i.e. near to the diaphragm, or to three slices, namely at the apex, hilus and base levels. According to Lu et al. (2001) both the one and the three slice methods lead to an overestimation of PEEP-induced recruitment in ARDS due to overrepresentation of the more recruitable upper lobes. However, a single CT scan slice, which is taken at the base of the lungs may underestimate PEEP-induced recruitment (Rouby et al. 2003).

CT Scan and the ARDS lung

CT scan has modified our view of ARDS pathophysiology and the management of ventilatory strategies (Rouby et al. 2003; Caironi et al. 2006; Gattinoni et al. 2006).

The lung in ARDS is characterised by a marked increase in lung tissue and a massive loss of aeration. The lower lobes are essentially nonaerated, whereas the upper lobes may remain normally aerated, despite a substantial increase in regional lung tissue. The overall lung volume and the cephalocaudal lung dimensions are reduced primarily at the expense of the lower lobes, which are externally compressed by the heart and abdominal content when the patient is in the supine position. Two opposite radiologic presentations, corresponding to different lung morphologies, can be observed in CT scans:

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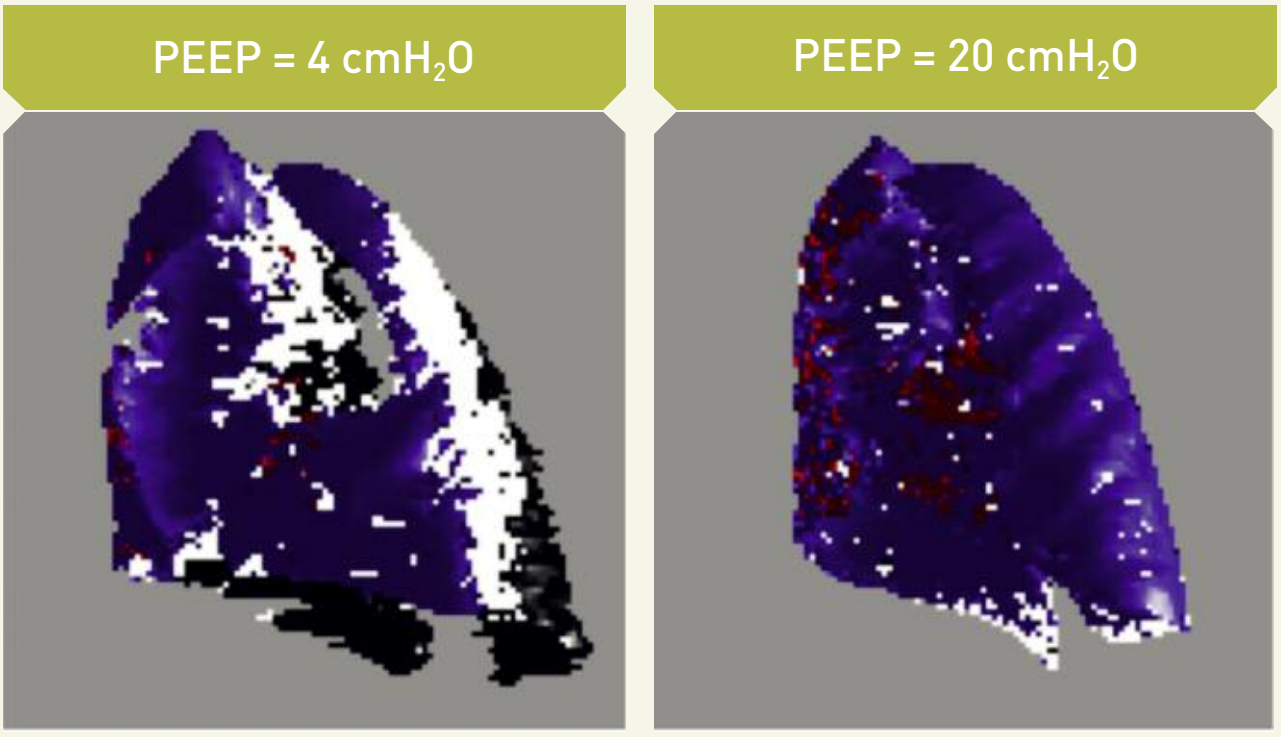


Figure 1. Hyperaerated (red), normally aerated (blue), poorly aerated (white) and non-aerated (black) compartments in whole lung computed tomography scans obtained from a pig under controlled mechanical ventilation in supine position, at different levels of positive end-expiratory pressure (PEEP). Note the increase of hyperaerated areas and decrease of non-aerated areas with increased PEEP.

focal and diffuse. When a positive airway pressure is applied to patients with focal loss of aeration, poorly aerated and nonaerated lung regions are recruited, whereas lung regions that are normally aerated at zero end-expiratory pressure tend to be rapidly overinflated, increasing the risk of ventilator associated lung injury. Patients with diffuse loss of aeration in CT scans may have recruited lung zones with less hyperinflated areas.

> *"…the use of CT might be included in algorithms to identify patients with higher or lower recruitment and possible individual mechanical ventilation setting of tidal volume, recruitment and PEEP, as well as the need for curarisation, prone position or extracorporeal lung support."*

CT Scan and the Diagnosis of ARDS

Several clinical definitions of ARDS have been proposed after its original description by Ashbaugh et al. (1967):

a) The American-European consensus conference definition (Bernard et al. 1994),
b) The "Dehli" score (Ferguson et al. 2005),
c) The Murray lung injury score (Murray et al. 1988), and
d) the "time dependent" definition (Villar et al. 2008).

Recently, the accuracy of these definitions has been addressed using the finding of diffuse alveolar damage on autopsy (Ferguson et al. 2005), with disappointing results. Thus, the correct identification of ARDS is still an open issue. Obviously, an inappropriate definition of ARDS may lead to biased results of clinical trials and lead to the rejection of therapies that might be useful.

Recent evidence suggests that the determination of lung weight by CT scan at PEEP 5 cmH_2O is useful to better define those patients who have higher degrees of oedema, alveolar collapse and higher risk of death (Gattinoni et al. 2006). Patients with lower lung weight seem to respond less to recruitment manoeuvres as compared to patients with higher lung weight.

THE RESPIRATORY CYCLE IN 150 IMAGES

Targeted recruitment maneuvers can help to reopen collapsed areas of the lungs. However, until now suitable information for immediately determining the success of such maneuvers has not been available. Dräger will help close this gap with the introduction of their new electrical impedance tomography device. It determines the regional distribution of ventilation in the lungs — continuously, without radiation, and directly at the patient's bedside.

In the course of time, new technical methods have provided fascinating insights that have facilitated the examination, therapy, and monitoring of patients. Pulse oximetry is a technique that enables the easy measurement of arterial oxygen saturation by measuring light absorption. Although this technique was almost completely unknown 25 years ago, today it is very difficult to imagine how rescue services or an intensive care unit (ICU) could operate without it.

The right pressure at the right time

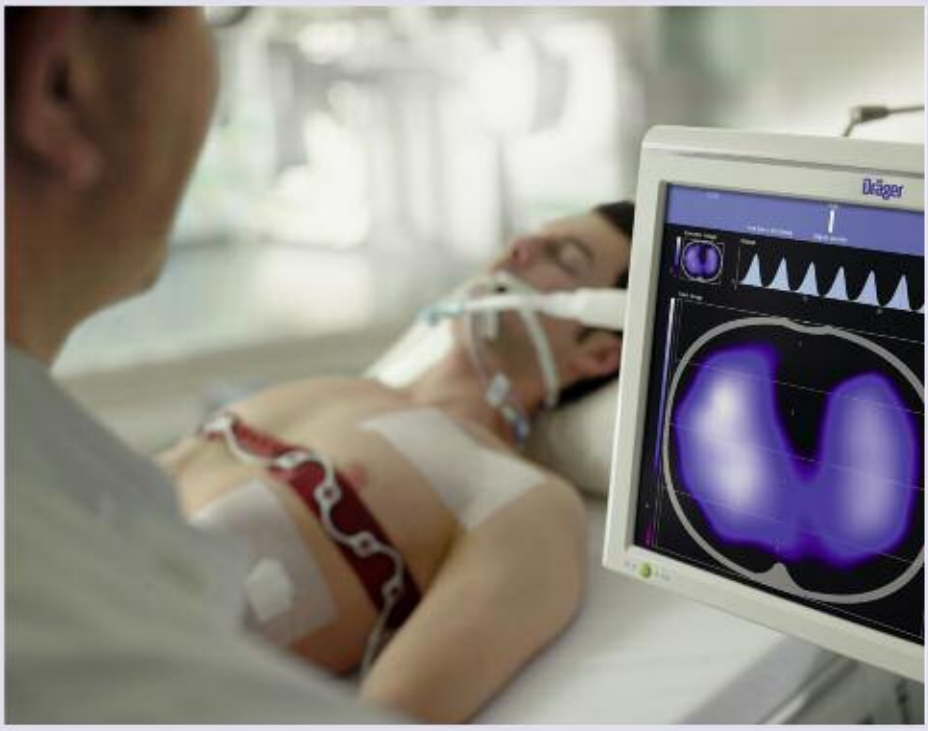
Today experts are predicting that electrical impedance tomography (EIT) will follow a similar path. Armed with this imaging method, it is possible to determine the regional distribution of ventilation in the lungs. "EIT has proved to be an efficient method for guiding ventilation therapy in patients with serious pulmonary diseases in such a way that consequential damage can be prevented," says Dr. Diederik Gommers, who is the vice chairman of the Adult Intensive Care Unit at Erasmus Clinical Center in Rotterdam, The Netherlands. "Especially in difficult cases where it's vital to act quickly, EIT provides us with up-to-date information that previously wasn't available." In theory, Dr. Gommers knows exactly the data he needs to treat these patients. Perhaps that's not so surprising given that he spent many years working on the research team of the experimental anesthesiologist Prof. Burkhard Lachmann. It was during this period that he codeveloped the Open Lung Concept. This concept provides important usage patterns for doctors when they have to make collapsed (atelectatic) regions of the lungs accessible for gas exchange again by using targeted recruitment maneuvers with temporarily high ventilation pressure. These regions of the lungs are subsequently stabilized by setting optimal positive end-expiratory pressure (PEEP).

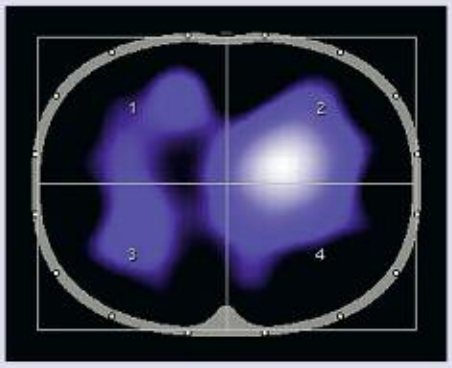
However, the practical implementation of this method had long proved to be difficult. "For the doctor to ventilate with the right pressure at the right time," explains Gommers, "he or she has to know pretty quickly how the various regions of the lungs respond to the individual recruitment maneuvers." That has not been possible up until now because no suitable method has been available. Although computed tomography (CT) provides a very detailed tomographic image of the lungs, the patient must first be transported from the ICU to the CT department — often a difficult and complex procedure. In addition, it is not possible to carry out continuous measurements because this method uses x-rays. Consequently, physiological processes such as respiration cannot be portrayed dynamically.

Functional residual capacity (FRC) is also of only limited use when it comes to assessing the success of targeted recruitment maneuvers. With this method, the gas volume remaining in the lungs following a normal expiration at rest is measured at regular intervals. EIT, like FRC, provides information about end-expiratory lung volume, but with the added benefit that EIT provides information about the response to recruitment maneuvers in specific regions of the lungs. In other words, EIT provides additional information and more specific guidance.

16 electrodes measure resistance

EIT provides a means of analyzing ventilation distribution in the lungs — the data is continuously displayed as images, waveforms, and parameters. To do so, it uses the fact that the air content influences the bioelectrical properties of pulmonary tissue. The more air that is contained in the pulmonary tissue, the greater is the electrical resistance, which in this case is specifically referred to as "impedance." In order to determine this impedance, Dräger has developed a solution in which 16 electrodes are first placed around the patient's chest. Tiny electrical currents are then applied to the body through one electrode pair and the resulting voltages at the remaining electrode pairs are measured. These voltages change in





∧ EIT image.

< Up to 50 images per second provide a dynamic picture of the ventilation at the bedside.

relation to the amount of air present in the patient's chest. Because the position at which the current is applied to the body during an EIT rotates around the chest, the voltage measurement locations also change. The measured values obtained after one 360-degree rotation can be used to compute a tomographic image that provides information about the distribution of air inside the chest (in the dorsal and ventral lung regions).

But that is by no means the end of the story. To resolve the change in the distribution of air with respect to time, EIT requires more than just a single snapshot. Instead — depending on the settings — up to 50 images are captured every second and respiration is continuously displayed as a dynamic image. One respiratory cycle lasting approximately three seconds generates a sequence of up to 150 images that show the ventilation distribution in the lungs in an intuitively understandable manner with the help of color coding.

Three colors (black, blue, and white) represent the ventilation of the lungs at a specific point in time in the individual regions of the lungs. White represents the regions that are best ventilated; non-ventilated regions are black. The blue areas represent regions that are in a transitory phase between black and white or vice versa. Finally, arranging the images chronologically results in an informative, dynamic image showing how these areas grow and recede in rhythm with the patient's respiration.

"This provides us with completely new insights into what is happening inside the patient's lungs," says Dr. Gommers when he is asked to describe his experience with EIT prototypes from Dräger. "What's more, thanks to the highly sensitive equipment we are able to optimize the fine adjustment of the ventilator directly at the patient's bedside."

Software is an important factor

It is the software that converts the measured data into comprehensible images which make the solution so usable. It was necessary to develop algorithms that condition the measured data so that only the relevant changes in bioimpedance as a result of ventilation are considered. Other disturbance variables, such as cardiac activity, can be subtracted so that the healthcare personnel can concentrate on the processes relevant to ventilation. The software also had to be written in such a way that the measured data can be continuously analyzed and visualized in real time bedside without delay.

Professor Ola Stenqvist, an anesthetist at Salhgrenska University Hospital in Göteborg, Sweden, has been following the advancements in this area very closely. He first became acquainted with the concept of EIT in the mid-1990s and has been a Dräger development partner since 2002. Says Stenqvist: "I believe that this product will represent a great advance in daily clinical practice as far as treating mechanically ventilated patients is concerned."

Dräger will launch its new EIT-device at ISICEM in March 2011.

Given that lung oedema is the hallmark of ARDS, patients who have lower lung weight possibly react differently to ventilation strategies and should be either excluded from clinical trials, or at least evaluated separately.

CT and the Origin of ARDS

Acute respiratory distress syndrome may result from a direct (ARDSp) or indirect (ARDSexp) insult to the lung parenchyma and the pathophysiology of the disease may differ according to the type of the insult (Rocco and Pelosi 2008).

Different studies have identified differences between ARDSp and ARDSexp in CT scans. Goodman et al. (1999) reported that in ARDSexp, ground-glass opacification was more than twice as extensive as consolidation. In contrast, in ARDSp a balance between ground-glass opacification and consolidation was observed. The authors also found differences in the regional distribution of the densities. In ARDSexp ground-glass opacification was greater in the central (hilar) third of the lung than in the sternal or vertebral third. In ARDSexp ground-glass opacification was evenly distributed across the lungs. Furthermore, the presence of air bronchograms and pneumomediastinum were prevalent in ARDSp, while emphysema-like lesions (bullae) were comparable in both groups.

According to Rouby et al. (2000), ARDSp is more frequently associated with diffuse and patchy loss of aeration in CT, whereas ARDSexp is more commonly accompanied by lobar loss of aeration.

CT Scans for Ventilator Settings in ARDS

ARDS requires a multifactorial therapy, including the specific therapy for the underlying disease, interventions in some of the molecular pathways leading inflammation or coagulation abnormalities and supportive therapies, mainly mechanical ventilation. CT scan may be useful to identify patients who will require "ultra-low" tidal volumes, i.e. lower than 6 mL/kg. Ultra-low tidal volumes can minimise stress and strain, but may require extracorporeal CO_2 removal.

CT scan may also be used to detect patients with higher or lower potential of lung recruitment. Gattinoni et al. (2006) evaluated 68 patients with ARDS by means of whole-lung CT scans at 5 cm H_2O PEEP and at 45 cm H_2O airway plateau pressure. Moreover, to assess the effects of the application of higher PEEP, they obtained a further CT scan of the whole lung at 15 cm H_2O PEEP. Thereby, those authors could identify patients responding to the recruitment manoeuvre and higher levels of PEEP. Our group suggested recently that the use of CT might be included in algorithms to identify patients with higher or lower recruitment and possible individual mechanical ventilation setting of tidal volume, recruitment and PEEP, as well as the need for curarisation, prone position or extracorporeal lung support (Rocco et al. 2010).

Conclusion

In conclusion, in the future the CT scan could play a relevant role to better define the optimal tidal volume and PEEP, as well as response to recruitment manoeuvres, in order to avoid excessive stress and strain. Studies investigating the clinical relevance of information from CT included in specific ventilation management algorithms are warranted. ■

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HOW SHOULD WE CONTROL BLOOD GLUCOSE IN 2011?

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Many studies, some already published a long time ago, have reported that hyperglycaemia (Dungan et al. 2009), or "dysglycaemia" (Smith et al. 2010) as some prefer, is an independent prognostic marker in acutely ill patients. For example, after cardiac surgery, glycaemia above 180 mg/dl, implying poor glucose control, was consistently and independently associated with an increased rate of postoperative infections and mortality (Furnary et al. 2003). The beneficial effects of lowering blood glucose to less than 150 mg/dl are well recognised and have been reported by retrospective analyses of large cohorts of critically ill patients (Falciglia et al. 2009).

The landmark Leuven I trial was a prospective, randomised controlled study that showed that "tight" glucose control (target blood glucose 80-110 mg/dl) improved survival and several secondary outcome variables (incidence of systemic infection, acute renal failure, need for transfusions polyneuropathy, duration of mechanical ventilation and length of stay in the intensive care unit [ICU]) (van den Berghe et al. 2001). However, seven independent confirmatory studies failed to reproduce these results (Annane et al. 2010; Arabi et al. 2008; Brunkhorst et al. 2008; De La Rosa et al. 2008; Finfer et al. 2009; Preiser et al. 2009; van den Berghe et al. 2006a). In the largest study, the NICE-Sugar study, there was even a worse outcome associated with tight glucose control (Finfer et al. 2009). Because of the lack of external validity of the findings of the Leuven I trial, recent evidence-based guidelines no longer recommend a tight target for blood glucose in critically ill patients (Ichai et al. 2010; Moghissi et al. 2009). Expert opinion and actual clinical practice commonly use an intermediate threshold to start insulin therapy, most often 140-150 mg/dl (Krinsley et al. 2008; Vincent, 2010). The feasibility and safety of tighter glucose control cannot be guaranteed unless considerable technological improvements become available.

The implementation of tight glucose control is a complex process, involving a number of important factors (Schultz et al. 2010). Each step of glucose control is critical, from the blood sampling, through choice of analyser and algorithm, to administration of the correct amount of insulin. Importantly, errors in insulin administration are the commonest therapeutic mistakes in the ICU (Garrouste-Orgeas et al. 2010). Moreover, certain physiological questions related to glucose control in critically ill patients remain unanswered, but suggest that the 'optimal' blood glucose target is still undefined. Indeed, rather than being a fixed target for all patients, it is likely that the 'ideal' blood glucose concentration varies in individual patients.

> *"…the 'optimal' blood glucose target is still undefined. Indeed, rather than being a fixed target for all patients, it is likely that the 'ideal' blood glucose concentration varies in individual patients."*

Based on these uncertainties and unresolved issues, what changes and progress can we expect in the near future? How can we move forward?

Better Delineation of the Risks Associated with Tight Glucose Control

The price to pay for tight glucose control includes an increased risk of hypoglycaemia and additional workload for the nursing staff. The incidence of hypoglycaemia, defined as the percentage of patients who experienced at least one episode of blood glucose of < 40 mg/dl, increased by a mean factor of 6 in patients randomised to tight glucose control with in-

tensive insulin therapy (Lacherade et al. 2009; Preiser et al. 2010). The mortality rate of the patients with hypoglycaemia was multiplied by a factor of 2.5 (Preiser 2009). Two independent sets of data (Egi et al. 2010)(Krinsley et al. unpublished data) suggest that the occurrence of even mild hypoglycaemia (< 80 mg/dl) is associated with increased mortality rates. Recently, Duning et al reported subtle neurocognitive dysfunction in patients who experienced hypoglycaemia during their ICU stay (Duning et al. 2010). The threshold used to define hypoglycaemia may, therefore, be different in ICU patients compared to the non-critically ill. In any case, avoidance of hypoglycaemia represents a key challenge during glucose control in the ICU. Likewise, high degrees of glucose variability, which are associated with poorer outcomes (Ali et al. 2008; Egi et al. 2006), are closely related to hypoglycaemia and its correction. Indeed, in vitro, large changes in glucose concentration of the culture medium of human cells is associated with cellular damage and increased oxidative stress and apoptosis (Risso et al. 2001). Hence, achievement of minimal glucose variability represents another major challenge of glucose control. A clinically relevant definition of glucose variability is also needed, as most of the many indices available have not been assessed in an ICU setting (Ali et al. 2009).

What is the Most Appropriate Glycaemic Target?

This key question is still unanswered. The most appropriate target is likely to be influenced by patient-related factors, such as the type and severity of critical illness and the medical history, and by ICU-related factors, e.g., staffing, available technology and local practice. Several lines of evidence support the absence of a universal 'optimal' blood glucose target in critically ill patients. In the ICU, the term 'normoglycaemia' is probably inappropriate for a blood glucose value between 80 and 110 mg/dl; these values are considered to rule out carbohydrate intolerance in fasting outpatients whereas critically ill patients undergo metabolic stress, are treated with medications that may increase blood glucose (catecholamines, steroids, etc) and are usually fed (Preiser 2008). Hyperglycaemia can also be viewed as a physiological consequence of the adaptive stress response (Dungan et al. 2009).

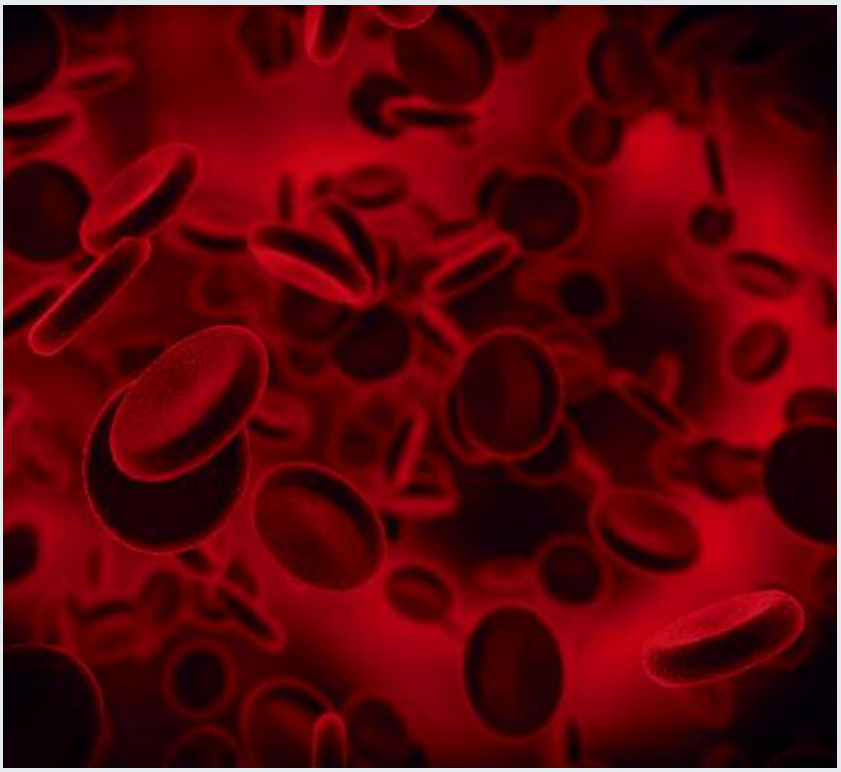
Additional physiological evidence supports different optimal blood glucose targets in specific situations. After brain injury, hypoglycaemia (< 80 mg/dl) and moderate hyperglycaemia (> 150 mg/dl) are both associated with poor outcome (Oddo et al. 2008; Vespa 2008). In patients with sepsis, no benefit was associated with the achievement of tight glycaemic control (Brunkhorst et al. 2008). In addition, in the Leuven cohorts (van den Berghe et al. 2006b) as well as in the patients of the Glucontrol and NICE-SUGAR studies (Finfer et al. 2009; Preiser et al. 2009), tight glucose control was not beneficial in the subsets of patients with pre-existing diabetes. Conversely, after cardiac surgery (two thirds of the patients in the Leuven I study), there was a clear benefit with tight glucose control (van den Berghe et al. 2001). Of interest, surgical patients treated with tight glucose control had a better outcome in surgical ICUs than surgical patients treated with tight glucose control in mixed ICUs (Friedrich et al. 2010).

Taken together, these findings support different 'optimal' blood glucose concentrations according to patient- and ICU-related factors.

Blood Glucose Measurement

Wide variations exist in the techniques used to measure blood glucose, including sampling site and the device used. Although widely used in ICUs, the accuracy and reliability of commercially available point-of-care (POC) devices are not sufficient, especially when capillary samples are used.

POC glucose readers use different measurement methods (amperometric or colorimetric reaction), enzymatic reactions (glucose oxidase or glucose dehydrogenase), calibration on total blood or on plasma, and different blood volumes, all of which lead to device-specific limitations, interference, and technical constraints that need to be taken into ac-



count when interpreting a blood glucose value. The reliability of the results depends on the user's knowledge of the device. Improved accuracy of POC devices is definitely needed in the lower ranges of blood glucose values, especially when capillary samples are used (Kanji et al. 2005; Vlasselaers et al. 2008). The current official requirements and international norms are based on data and therapeutic requirements for diabetic, but not critically ill patients. For example, the Clarke error grid introduced in 1987 and used to evaluate the therapeutic implications of inaccuracies of glucose readers (Clarke et al. 1987) is not adapted for insulin algorithms currently used in ICUs. Improvements in POC technology need to include the introduction of correction factors or compensation for interference and sampling site. Assessments of performance also need to be carried out in an ICU environment.

Continuous glucose monitoring will probably represent a major step forward, initially for clinical research and later for clinical use. Some experience with subcutaneous continuous glucose monitoring has already been reported (Brunner et al. 2011; Corstjens et al. 2006), but the accuracy of these devices is currently too low in haemodynamically unstable patients. The major hope lies in continuous intravascular glucose monitoring. Limited clinical data, using various techniques (enzymatic, microdialysis, optic fibre), have been published (Rooyackers et al. 2010), but several companies are currently developing new prototypes, which will be evaluated in the near future (Fahy et al. 2008; Joseph et al. 2009; Mraovic 2009). The methods by which these continuous glucose sensors are evaluated will hopefully also be standardised.

> "Computer-based algorithms can improve the quality of glucose control (Juneja et al. 2009), as long as individual patient characteristics are incorporated and taken into account in the calculation of the insulin infusion rate."

Insulin Algorithms

A large number of insulin algorithms are used today (Wilson et al. 2007). Use or misuse of these algorithms can partially explain the discrepancies in the results from the large clinical trials on tight glucose control. Although there is consensus regarding the preferential use of dynamic scales, the comparison of algorithm performance if not standardised (Eslami et al. 2008). Computer-based algorithms can improve the quality of glucose control (Juneja et al. 2009), as long as individual patient characteristics are incorporated and taken into account in the calculation of the insulin infusion rate. For example, Lonergan et al. (2006) developed and validated a protocol which included the actual insulin sensitivity. Using this protocol, the quality of glucose control in the Glucontrol study (Preiser et al. 2009) would have been improved (Suhaimi et al. 2010).

Closed-Loop Systems

The ultimate innovation in the field could be the development of closed-loop systems that mimic an artificial pancreas. In such techniques, (near-) continuously measured blood glucose values can be fed into computerised systems which then adapt the insulin infusion rate accordingly, taking into account specific patient- and treatment-related variables. Preliminary data with closed-loop systems have already been published, and suggest that this approach may decrease variability in blood glucose concentrations (Yatabe et al. 2011) but further clinical studies are needed to determine whether this effect can influence outcomes.

Conclusion

Much has changed in our approach to blood glucose concentrations in critically

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Nihon Kohden is redefining Quality of Care with new, non-invasive technologies like PWTT and esCCO™ by introducing volumetric information to all care levels. Since the invention of pulse oximetry by Nihon Kohden researcher Takuo Aoyagi in 1974[1], the pulse wave has become the most commonly used vital signal in clinical practice. The pulse wave can provide time related information such as intravascular pressure transmission as well as information on the volume change of arterial blood. Estimated Continuous Cardiac Output (esCCO) is a new technology to determine the cardiac output using Pulse Wave Transit Time (PWTT) which is obtained by the pulse oximetry and ECG-signals from each cycle of the ECG and peripheral pulse wave. esCCO provides real-time, continuous and non-invasive cardiac output measurement alongside the familiar vital sign parameters of ECG and SpO_2.

Principle of esCCO

The possibility to derive the cardiac output from pulse pressure information by,

$$CO = SV \times HR = (K \times PP) \times HR$$

[CO: cardiac output; SV: stroke volume; K: constant value; PP: pulse pressure; HR: heart rate] established in various continuous cardiac output systems using the pulse-contour-analysis, built the starting point for the novel technology esCCO™. A better correlation between SV and PWTT was observed compared to that between SV and PP[2], and the formula providing cardiac output values was determined to be expressed by PWTT-Information as follows;

$$CO = SV \times HR = K \times (\alpha \times PWTT \times \beta) \times HR = esCCO$$

[α, β: experimental constants]

Performance of esCCO

Ishihara et al. reported that esCCO™ derived from PWTT-Information is highly correlated with cardiac output determined by thermodilution technique[3]. In 2009, a multi center study at seven facilities verified the effectiveness of esCCO as a practical application (Fig 2).

Reliable Measurement with Non-Invasive Calibration

The ambition in research and development though, was the provision of volumetric informa-

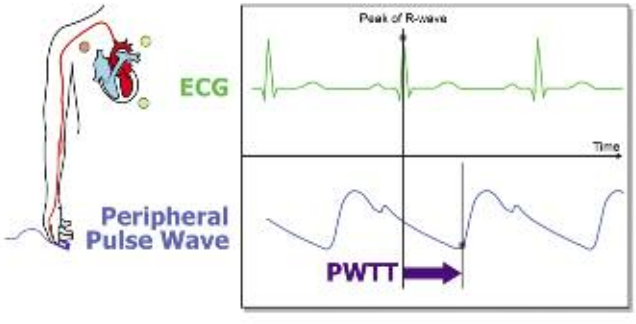

Figure 1: Pulse Wave Transit Time derived from ECG and pulse oximetry signal

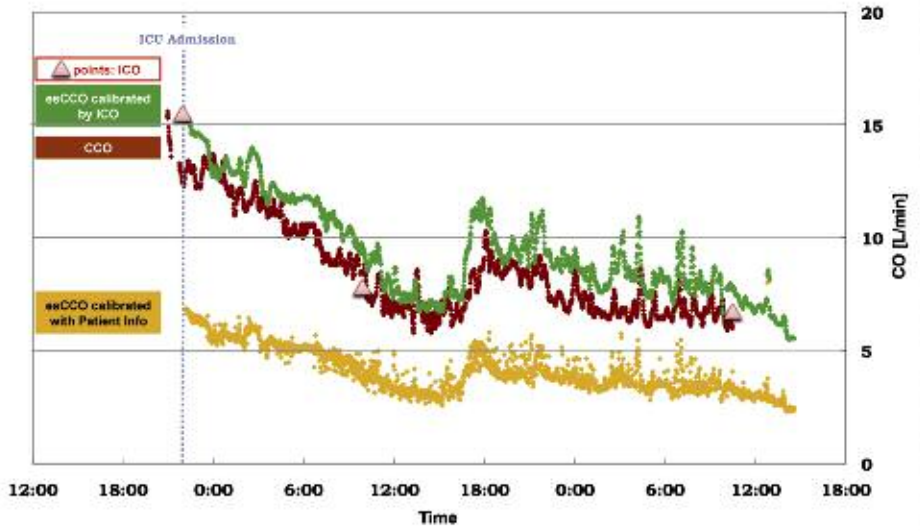

Figure 3: Comparison of esCCO™, ICO, CCO in ICU post liver transplantation. Postoperative change in cardiac output of a liver transplantation patient in intensive care unit (ICU).

Cirrhosis is accompanied by various cardiovascular abnormalities which increase cardiac output (CO) and decrease arterial blood pressure and vascular resistance5). Therefore, perioperative monitoring of these parameters is extremely important for liver transplantation patients. Figure 3 shows trend of esCCO observed in ICU after liver transplantation. The cardiac output by cold bolus thermodilution (ICO) is given by red triangle. The esCCO, which was once calibrated by ICO on ICU admission, was in excellent agreement with ICO and CCO (brown line) measured by pulmonary artery catheter. Despite the underestimation of CO due to decreased vascular resistance, esCCO calibrated with patient information (gold line) shows an equivalent trend to CCO. These results indicate that esCCO has a promising performance for tracking change in CO after removal of pulmonary artery catheter.

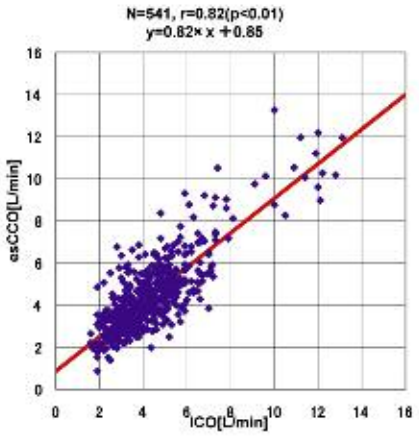

Figure 2: Comparison between esCCO™ and cardiac output by cold bolus thermodilution (ICO) [4]

tion, especially for mid and low care levels, to improve patient care and enhance patient safety. With that, the challenge was to avoid any kind of invasive or minimal-invasive calibration.

By only entering patient information such as age, gender, height and weight, and an initial NIBP measurement, esCCO™ determines a reference value for calibration and is ready for start the measurement. Additionally, a cardiac output value obtained by other CO devices such as by pulmonary artery catheter can be used for calibration. Both calibration modes reliably track changes in cardiac output and provide advanced monitoring of a patient's hemodynamic status (Fig 3).

Enhanced Hemodynamic Monitoring at No Extra Cost

Provided over the Nihon Kohden Patient Monitoring Series, esCCO™ represents a care enhancing and economic solution as no additional running costs (accessories) related to the regular use of the monitor appear.

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Early Decision Making in Goal Directed Fluid Management

Life Scope J

ill patients over the last decade. The Leuven studies encouraged us to pay greater attention to maintaining blood glucose at levels much lower than had previously been considered necessary. But the risks of tight glucose control then became apparent along with realisation that variability in blood glucose concentrations was also relevant to outcomes. The development of techniques to continuously monitor blood glucose levels will help follow blood glucose levels more closely and closed-loop systems by which insulin doses will be adjusted automatically according to continuous blood glucose readings and adapted to individual patient characteristics are just over the horizon. Until then, blood glucose levels below 150 mg/dl should be targeted and attempts made to limit variations in blood glucose levels as much as possible (Vincent 2010). ■

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NEW DEVELOPMENTS IN RENAL REPLACEMENT THERAPY (RRT)

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Renal replacement therapy (RRT) is now widely used within intensive care units (ICU) but despite its broad acceptance, there remains a general lack of consensus or recommendations regarding best practice. Despite these limitations, the interest in acute kidney injury (AKI) as well as blood purification techniques continues to grow with many small studies and a few precious large multicentre randomised controlled trials (RCT) although those that have been published so far have provided useful information. This review will address the 'hot topics' in RRT that involve the intensive care world and the latest developments and recommendations will be outlined.

First, the debate still remains ongoing as to the best technique for provision of RRT in our ICU patients including: Intermittent haemodialysis (IHD), continuous veno-venous haemodiafiltration (CVVHDF), continuous veno-venous haemofiltration (CVVH), Sustained low efficiency dialysis (SLED) and others. This debate continues to rage with two major questions: Continuous or intermittent techniques and diffusion or convection. A large RCT, the Haemodiafe study by Vinsonneau (Vinsonneau et al. 2006), compared IHD versus CVVHDF for ICU patients and showed that the techniques are comparable in term of patients' outcome and this was subsequently confirmed by another RCT. However many intensivists remain in favour of continuous methods especially where the patient is haemodynamically unstable. Although some groups have reported no overt problems using IHD for unstable patients in the ICU (Fieghen et al. 2010; Schortgen et al. 2000), most of the expert opinion recommends continuous therapies, particularly during the acute phase of AKI and in particular for patients with haemodynamic impairment or the impact on drug removal (Bagshaw et al. 2008; Susla 2009).

The choice between diffusion and convection also remains unclear. Diffusion permits efficient removal of small molecules with an excellent ionic equilibration whereas convection is more efficient for 'middle molecule' removal, but when employing a high cut off membrane, the dialysis technique also has the capability to remove larger molecules (Messer et al. 2009; Ricci et al. 2006). However, no large RCT has demonstrated any clear superiority of one method over the other in terms of outcome improvement despite the superiority of large pore membrane reported in small studies (Morgera et al. 2006). A new generation of membranes has also emerged with specific properties as endotoxin adsorption (Toraymyxin® from Toray™ or Oxiris® from Gambro™) or specific immuno-adorsption (Prosorba® from Fresenius™) with promising results in recent studies (Cruz et al. 2009) and the promise of RCTs in the near future.

> *"Early use of RRT may also be relevant in patients treated by Extra-corporeal membrane oxygenation (ECMO) for severe acute respiratory distress syndrome (ARDS) as shown in some very recent studies and in particular in children."*

The dose of fluid exchange that we have to provide is now more clearly defined giv-

en the publication of the two large RCTs within the last few years. The study by Ronco et al in 2000, recommended a dose of haemofiltration for ICU patients of 35 ml/kg/h (Ronco et al. 2000). This new paradigm of beneficial effect in increasing RRT dose was further addressed by two large studies: One showed better outcomes for patients treated by daily haemodialysis rather than three times a week (Schiffl et al. 2002), the other that increasing dose and adding a dialysis treatment to haemofiltration also improved outcome (Saudan et al. 2006). However, the large multi-centre RCT conducted by Palevsky and collagues in 2008 showed that less intensive therapy (IHD three times a week, CVVHDF at 20 ml/kg/h or SLED) is comparable to intensive therapy (daily dialysis or CVVHDF at 40 ml/kg/h) (Palevsky et al. 2008). The definitive answer to this question came from the RENAL study that clearly demonstrated no beneficial effect of CVVHDF at 40 ml/kg/h in comparison with 25 ml/kg/h (Bellomo et al. 2009). Therefore, the consensus currently is that the dose of haemofiltration employed should be 25 ml/kg/h with no additional benefit from a dose increase. However, two points remain unanswered. First, most experts agree that patients should not be undertreated and to deliver at least 25 ml/kg/h of fluid exchange. In practice this recommendation implies prescribing 30-35 ml/kg/h to take into account the predictable (bags change, nursing…) or unpredictable breaks in treatment (surgery, clotting…) (Vesconi et al. 2009). Secondly, the debate about the dose remains open for septic patients as some small prospective or randomised studies have shown a beneficial effect of high dose haemofiltration (Honore et al. 2000; Joannes-Boyau et al. 2004; Boussekey et al. 2008). The multicentre RCT "IVOIRE study" compares haemofiltration at 35 ml/kg/h versus 70 ml/kg/h for patients with septic shock, AKI and multiple organ failure may bring some important information to this area in the near future (Joannes-Boyau; In progress).

When to commence RRT is also a major question. This was hampered in the past by a lack of a clear and consensual definition of acute kidney injury to enable stratification of the degree of renal impairment and to homogenise patients for study purpose and to help to define the best moment to start RRT. Fortunately, two new classifications have arrived within the last few years: the RIFLE criteria and AKIN (Cruz et al. 2009). These classifications alert aware clinicians about the presence of AKI and to allow early intervention. Some studies or meta-analysis published in the last few years have possibly fuelled interest for commencing RRT early but large RCT's to define the best moment to start are awaited (Shiao et al. 2009;

Seabra et al. 2008). One RCT regarding timing to start haemofiltration was negative (Bouman et al. 2002), but this was insufficiently powered and the patient population was too selective (post-cardiac surgery). Again, expert recommendations imply that

commencing RRT earlier and in particular in the septic patient where we know that AKI is often progressive. However, a RCT from France has shown that it is probably not recommended to start RRT before AKI criteria have been fulfilled (Bouman et al. 2002) and some concerns have emerged from a Belgian study (but not randomised) about the possible harm of starting RRT too early (Elseviers et al. 2010). It seems acceptable to start RRT at the Injury level of RIFLE criteria (or stage 2 of AKIN) at least for septic AKI, especially when associated with shock but no consensus has emerged at present and large RCTs are needed. Early use of RRT may also be relevant in patients treated by Extra-corporeal membrane oxygenation (ECMO) for severe acute respiratory distress syndrome (ARDS) as shown in some very recent studies and in particular in children (Ricci et al. 2010; Santiago et al. 2009).

Anticoagulation remains a field of continuous development and research, in particular since the description of citrate anticoagulation and new dedicated machines. Despite the fact that unfractionated heparin (UFH) remains the most commonly use anticoagulant around the world for RRT, citrate and other alternatives begin to assume more importance. The most recent important study was provided by Oudemans van Straaten and coll where they compared citrate anticoagulation to low molecular weight heparin (LMWH) but only in the surgical subgroup (Oudemans-van Straaten et al. 2009). Although no difference was found in terms of efficacy, they found an unexplained improved outcome for patients treated with citrate. In fact, the three-month mortality is probably abnormally high in the LMWH group (63%) when compared with the expected death rate in such patients with the citrate group being closer to the usual outcome (48% mortality). Thought must also be given to antithrombin levels when using UFH during RRT as it is a mandatory clotting co-factor (and sometime forgotten) although its activity level is often reduced, particularly in septic ICU patients and need to be supplemented (Lafargue et al. 2008).

The last point is the one concerning the replacement fluids, where new products on the shelf are becoming closer to the plasma composition, in particular with phosphorus implementation directly in the fluid bag (Broman et al. 2010), which can avoid severe ionic disturbances shown in the past (Bellomo et al. 2010).

In conclusion, more and more developments are occurring in the field of RRT. Large RCTs on various key subjects are warranted to try to improve our knowledge and save more lives as patients suffering from AKI in ICU continue to have an unacceptably high mortality rate. In the meantime, the odyssey in the RRT universe will continue for the intensivists, enabling them to expand our knowledge in this exciting field. ■

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THE CHANGING FACE OF ABDOMINAL COMPARTMENT SYNDROME

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The management of intra-abdominal hypertension and abdominal compartment syndrome has evolved resulting in significantly improved patient survival. This article discusses recent cutting-edge changes in the management of such patients.

Introduction

Intra-abdominal Hypertension (IAH) and Abdominal Compartment Syndrome (ACS) are significant causes of morbidity and mortality among critically ill medical, surgical, and paediatric patients (Ivatury et al. 1998; Malbrain et al. 2005; Ejike et al. 2007). IAH/ACS management has evolved significantly in recent years resulting in both improved survival and decreased resource utilisation (Cheatham and Safcsak 2010). Key factors in this improved strategy include earlier diagnosis, comprehensive medical management, and rapid surgical intervention for refractory ACS (Cheatham 2009; Cheatham and Safcsak 2010). The purpose of this brief review is to discuss recent cutting-edge changes in the management of patients with IAH/ACS.

Definitions

Intra-abdominal pressure (IAP) is the pressure within the abdominal cavity. It may be pathologically elevated in patients with haemoperitoneum, ascites, space occupying lesions (such as tumor or abscess), intestinal gas, viscera oedema (as occurs in severe sepsis and shock), and decreased abdominal wall compliance. Normal IAP is negative or near 0 mmHg. An IAP of 10-15 mmHg is prevalent in critically ill intensive care unit (ICU) patients (Malbrain et al. 2005). IAPs in excess of 20-30 mmHg are common in patients with an acute abdomen or sepsis and can result in significant organ dysfunction, organ failure, and even death (Cheatham and Safcsak 2010). IAP is routinely determined using intravesicular or bladder pressure (IVP) (Malbrain et al. 2006). The World Society of the Abdominal Compartment Syndrome (WSACS) consensus guidelines recommends that patients with risk factors for IAH/ACS receive serial IAP measurements throughout the duration of their critical illness (http://www.wsacs.org).

IAH is defined as an IAP ≥ 12 mmHg while ACS is defined as prolonged elevation of IAP > 20 mmHg with new onset organ dysfunction (Malbrain et al. 2006). Common signs of ACS include:

- Refractory hypotension,
- Oliguria,
- Metabolic acidosis,
- Hypoxemia,
- Elevated peak inspiratory pressures,
- Hypercarbia, and
- Elevated intracranial pressure.

ACS may occur in medical, surgical, and paediatric patients as a result of sepsis, pancreatitis, trauma, burns, or critical illness. Unrecognised or untreated, ACS has a reported mortality of up to 100%.

Recent Advances

A decade ago, ACS was considered by many clinicians to be a diagnosis for which little could be done. The management of IAH/ACS has, however, changed tremendously in recent years. While emergent surgical decompression of the abdomen was previously the only treatment available, improved diagnosis and resuscitation through both non-operative and minimally invasive therapy have resulted in significant improvements in patient survival (Cheatham and Safcsak 2010).

Medical Management

Abdominal decompression, especially if performed late in the course of ACS, is associated with significant morbidity including enteroatmospheric fistula, fluid and electrolyte imbalance, accelerated protein loss, chronic ventral hernia, and increased resource utilisation, making the "open abdomen" a challenge to even the most experienced practitioner. Given the complexity of such patients, many clinicians have been reluctant to employ abdominal decompression in patients with ACS despite ample evidence that it is commonly life-saving.

Recently, a variety of less invasive methods for treating IAH/ACS have shown promise, bringing effective IAH/ACS therapies to the armamentarium of intensivists as well as surgeons. These non-operative medical interventions have been described in the management algorithm proposed by the WSACS and based upon their evi-

dence-based medicine consensus guidelines (Figure 1).

Directed by the results of serial IAP monitoring, this multi-modality strategy is based upon five general principles:

1) Evacuation of intraluminal contents
2) Evacuation of space occupying lesions
3) Increasing abdominal wall compliance
4) Optimising fluid administration
5) Optimising regional perfusion

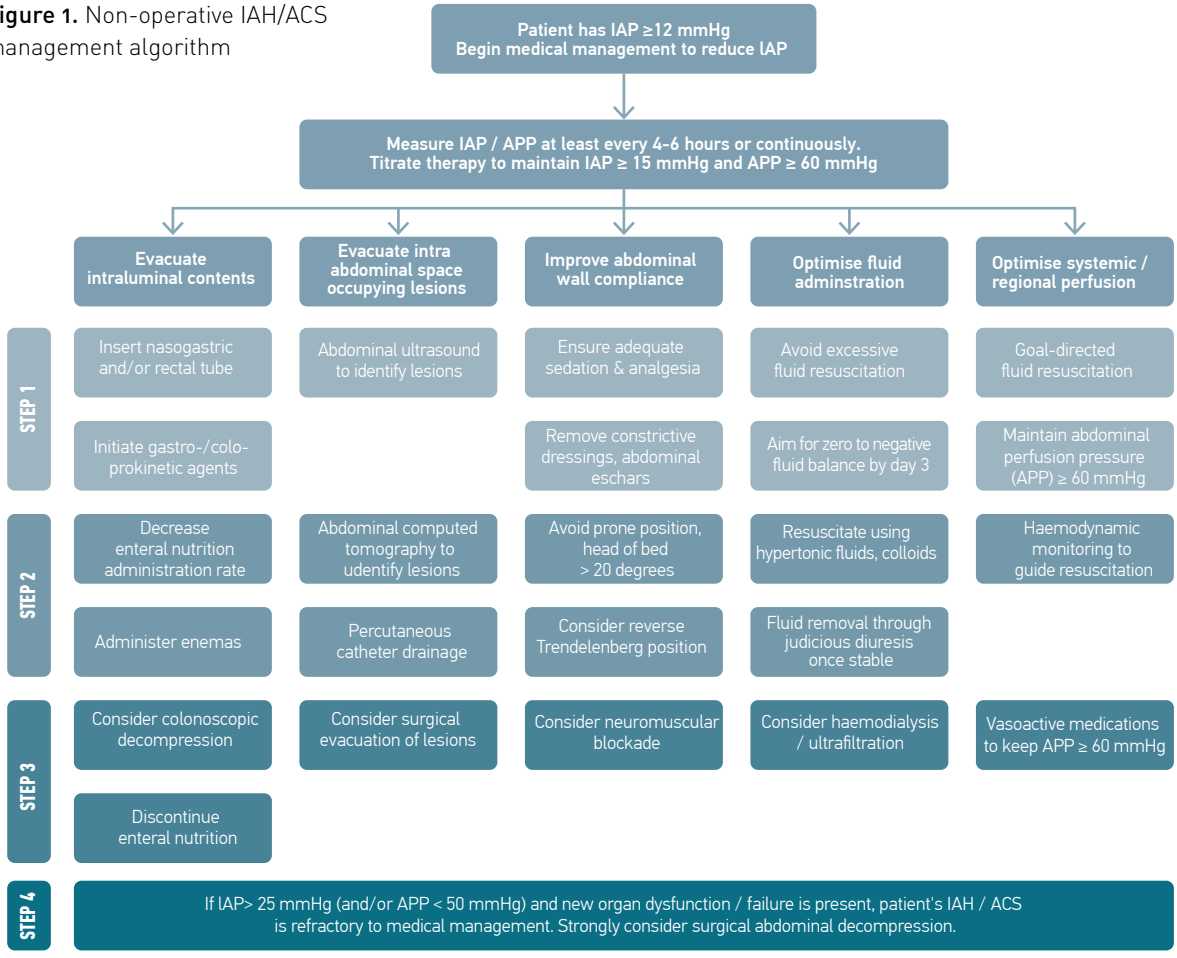
These medical interventions, instituted in a staged fashion according to the patient's severity of illness, degree of IAH, and response to less invasive therapies, have been demonstrated to decrease the progression of IAH to ACS, decrease the need for surgical intervention, and significantly improve patient survival (Cheatham and Safcsak 2010).

Peritoneal Fluid Evacuation

The peritoneal fluid of patients with sepsis, pancreatitis, and multiple organ dysfunction is filled with pro-inflammatory mediators (Souza et al. 2010; Kubiak et al. 2010). This cytokine-rich ascitic fluid may serve as a second hit phenomenon in the critically ill resulting in further organ dysfunction and failure. Peritoneal fluid removal through paracentesis, peritoneal lavage, or continuous suction from the open abdomen has been shown to significantly reduce peritoneal and/or serum tumor necrosis factor-alpha, interleukin (IL)-1β, IL-6, IL-8, and IL-12 levels. More importantly, this therapy results in improved organ function in the presence of elevated IAP. Kubiak et al. demonstrated significant improvements in both renal and pulmonary dysfunction among septic pigs when peritoneal fluid was actively removed using negative pressure wound therapy (Kubiak et al. 2010).

Advances in Open Abdomen Management
In the early days of surgical decompression for IAH/ACS, the open abdomen was a tool of last resort, associated with a both a high rate of entero-atmospheric fistula formation and a near ubiquitous requirement for split-thickness skin grafting of the exposed viscera and subsequent repair of the resulting

Figure 1. Non-operative IAH/ACS management algorithm



IAP – intra-abdominal pressure **APP** – abdominal perfusion pressure (calculated as mean arterial pressure minus IAP)
IAH – intra-abdominal hypertension **ACS** – abdominal compartment syndrome
Used with the permission of the World Society of the Abdominal Compartment Syndrome

massive incisional hernia. Advances in open abdomen management, supported by earlier decompression in patients with signs of IAH/ACS, have dramatically increased the rate of primary fascial closure at time of discharge to over 80% in some centres (Kimball et al. 2009). One such advance is the application of specialised vacuum assisted wound closure dressings to the open abdomen. These allow more effective removal of cytokine-rich peritoneal fluid, increased protection for the exposed viscera, and improved fascial closure rates (Batacchi et al. 2009; Cheatham and Safcsak 2010). The availability of new bioprosthetic mesh implants as well as the development of new surgical techniques have also improved the likelihood of successful abdominal closure.

Efficacy of a Multimodality Approach to IAH/ACS

The WSACS consensus recommendations are based on four principles:

1) Serial IAP monitoring;
2) Goal-directed optimisation of systemic perfusion and organ function;
3) Medical interventions to reduce IAP and IAH-induced end-organ damage; and
4) Prompt surgical decompression for IAH/ACS that is refractory to medical management.

Cheatham et al. recently published (2010) a prospective observational study of 478 patients with IAH/ACS requiring open abdominal decompression both before (2002-2004) and after (2005-2007) release of the WSACS guidelines (initially proposed in 2005).

While patient severity of illness remained unchanged throughout the study, patient survival improved significantly from 50% to 72% through adherence to the guideline ($p=0.015$).

Other improved patient factors included:

- Decreased mean days to abdominal closure (20 vs. 10 days; $p< 0.01$),
- Decreased entero-atmospheric fistula rate (8.6% vs. 3.6%; $p< 0.05$), and
- Decreased requirement for split-thickness skin grafting to close the abdomen (12% vs. 3%; $p< 0.01$).

Development of ACS, prophylactic abdominal decompression, and use of the WSACS algorithm were identified as independent predictors of survival. Kimball et al. similarly performed a prospective study of 600 patients at risk for IAH/ACS who were managed according to a standardised protocol (Kimball et al. 2009). Reductions in ICU length of stay (14.5 vs. 10.5 days), ventilator days (12.3 vs. 8.3 days), and need for emergent abdominal decompression (23.2% vs. 13.8%) were realised.

> "...improved diagnosis and resuscitation through both non-operative and minimally invasive therapy have resulted in significant improvements in patient survival".

Conclusions

IAH/ACS is commonly encountered in the critically ill. Tremendous progress has been made toward improved management of such patients with decreased morbidity and improved long-term functional outcome. An evidence-based medicine approach emphasising earlier diagnosis, multi-modality medical management, and surgical intervention for refractory ACS has been demonstrated to significantly improve patient survival. ■

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The Multi-Organ Effects of a Vicious Cycle
What Happens to the Body's Organs?
Intra-Abdominal Pressure and Intra-Abdominal Hypertension

Intra-Abdominal Pressure

Most critically ill patients have a significant systemic inflammatory response (SIRS) that triggers the release of cytokines leading to capillary permeability and interstitial edema. Abdominal viscera are particularly vulnerable as tissue edema worsens with the third spacing of resuscitative fluid. As visceral edema worsens intra-abdominal pressure (IAP) increases. As IAP increases perfusion to abdominal organs decreases resulting in compromise to visceral blood flow and tissue ischemia. Tissue ischemia then perpetuates further cytokine release and worsening systemic inflammation thus initiating the *vicious cycle*.

Intra-Abdominal Hypertension

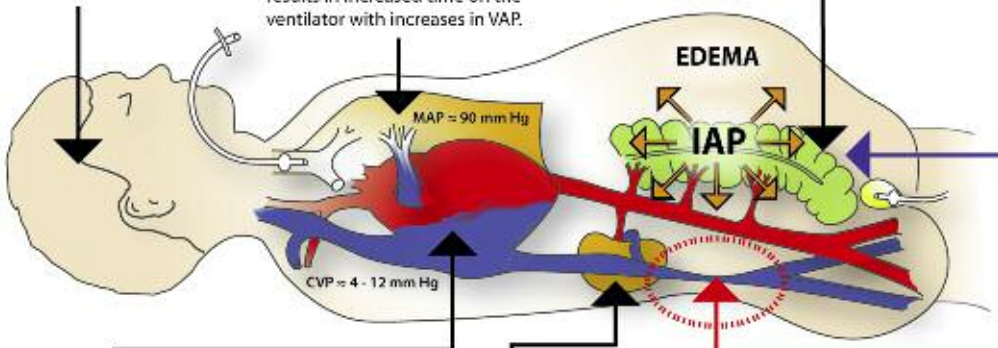
Intra-Abdominal Hypertension (IAH) is defined as Intra-Abdominal Pressure (IAP) above 12 mm Hg [1]. At which point significant tissue perfusion problems arise, which can lead to early organ dysfunction. An IAP level over 20 mm Hg typically causes organ failure and is called Abdominal Compartment Syndrome [1].

Fluid resuscitation for critical illness → **Total body fluid third spacing/edema** → **Elevated intra-abdominal pressure due to bowel edema** → **Vena cava compression**

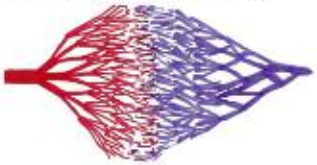
Brain: IAP elevation can directly contribute to ICP elevation.

Lungs: IAP pushes diaphragms into chest, raising intrathoracic pressure causing an increase in barotrauma, hypercarbia and hypoxemia. This results in increased time on the ventilator with increases in VAP.

Intestines: IAP compromises intestinal blood flow resulting in ischemia, necrosis and multisystem organ failure.



Impact of IAH on capillary blood flow to abdominal organs:



If IAP exceeds 15 to 20 mm Hg capillary blood flow is dramatically reduced, leading to anaerobic metabolism, increased cytokine production and exacerbation of capillary permeability (worsening bowel edema). At IAP levels approaching 20 mm Hg venous return to the heart is impaired reducing cardiac output. Decreases in systemic blood flow (CO) compounds the insult of direct tissue ischemia perpetuating the *vicious cycle*.

Heart: Cardiac monitoring, including CVP and PCWP, are artificially elevated by IAP making them difficult to interpret in the IAH setting.

Kidneys: Reduced kidney perfusion and urine production results in inability to mobilize fluids and increased rates of renal insufficiency/failure.

Vena Cava Compression: IAP greater than 8-12 mm Hg results in reduced blood flow to the heart (preload).

Reduced blood flow to heart (preload) → **Reduced cardiac output** → **Reduced blood flow to organs** → **Multi-system organ dysfunction/failure**

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[1] Results from the International Conference of Experts on Intra-abdominal Hypertension and Abdominal Compartment Syndrome II. Recommendations Intensive Care Medicine 2007

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THE QUEST FOR LEADERSHIP AND STRIKING THE PERFECT WORK / LIFE BALANCE

AN INTERVIEW WITH **DEREK ANGUS**

Professor and Chairman of the Department of Critical Care Medicine, Derek C. Angus is also Professor of Medicine and Health Policy and Management at the University of Pittsburgh School of Medicine and UPMC. Dr. Angus is also the director of the Clinical Research, Investigation and Systems Modeling of Acute Illness (CRISMA) centre at the University of Pittsburgh School of Medicine. Dr. Angus took some time out of his busy schedule to share his thoughts on integrating IT in the ICU, the importance of leadership skills and the struggle for the perfect work / life balance with Managing Editor Sherry Scharff.

Could you briefly describe your department?

We run 250 ICU beds in several different hospitals caring for both adult and paediatric ICU populations. We have around 15 specialised units under this umbrella including med-surg ICUs, cardiothoracic ICUs, trauma ICUs, medical ICUs, paediatric ICUs and neuro ICUs, each containing 10-25 beds. In terms of physician staffing, we have about 90 attendings and 50 fellows in the department. There are about 100 nurses per ICU, with a nurse to patient ratio of two to one or higher, based on unit and level of need. We also have respiratory therapists dedicated to the ICUs as well as ICU pharmacists, physical therapists, occupational therapists, and social workers.

What goals do you strive to meet in your current position?

Our department has education, research and clinical missions. In each of these domains, we have different things we are trying to do. With the clinical mission, it is always a constant challenge to move towards more standardised care. We are currently involved in a number of initiatives to better leverage information technology for better, more standardised ICU care. These efforts include better patient surveillance both in the ICUs and on the floors. We run all the outreach teams for the hospital floors, we run a paediatric critical care transport service for the region, and we are interested in improving regional ICU services delivery for all patients across south western Pennsylvania. For most clinical problems, we serve a catchment area of about 14 million people, including western part of Pennsylvania, the northern half of West Virginia, and the eastern half of Ohio. In addition, for a number of services, such as management of fulminant hepatic failure, we will take patients from a far wider area.

You mentioned the use of IT in your units…

We use computerised physician order entry, we have a complete electronic medical record, all our imaging is digital, and all of our rounds are done with a mobile cart, which all operate wirelessly and connect to our electronic medical records system. Thus, a lot of the infrastructure is already there. However, the use of that system for electronic prompts for quality improvement and for standardisation of treatment practices is still an ever-consuming process. We can embed applications into the existing system, but the problem is that each new initiative involves a lot of time working with programmers and educators. In addition, every new alarm or prompt has to be field tested to ensure we don't induce alarm fatigue, or accidentally distort care with unintended consequences. At this point, we do have fairly robust prompts for many common ICU practices, such as ventilator weaning, checks for potential drug reactions, antibiotics usage, DVT prophylaxis, blood sugar control, and so on. However, there is certainly still a long way to go in terms of what we could do to further utilise this system in standardising practices from unit to unit.

In addition, most of our beds are in the big teaching hospitals in the UPMC system, but of course there are 20 hospitals in the system and in the more peripheral hospitals, we have less of an influence. So, collaborating with those physicians working in those outlying hospitals is important in support of our long-term goal of more integrated care.

What is your greatest interest in the world of critical care?

Well I like sepsis.

Well who doesn't…?

Well it does hold a fair amount of interest… as does pneumonia and multi-system organ failure. I'm lucky to run a research group that has grown considerably over the last ten years. And, as it has grown, the research port-

folio has expanded. Along the way, my own curiosity has been stimulated by all our faculty and projects. Today, we now have several programmes within CRISMA, each with different programme directors. As the overall director, I have a certain amount of passion for each of the arms. In addition to interventional trials in sepsis, I remain very interested in research into health policy and cost effectiveness, especially those studies tackling the causes of unwanted regional variation and efforts to minimise unwanted variation. Another area of interest is to explore ways to develop more sophisticated patient phenotyping for better trial design, such as theragnostics, where treatment is guided by particular biomarkers.

Utilising biomarkers is certainly an area of interest for many of our readers…

To that end, we have several biomarkers studies currently underway. We also maintain a large "bio-bank" of frozen blood and urine samples from thousands of patients from different cohort studies and randomised trials. We use these samples to look at potential genetic biomarkers as well as cellular and circulating biomarkers, mainly in the areas of pneumonia, sepsis, acute lung injury and acute kidney injury. The other area that has been interesting for me is to think about critical illness in the context of under-resourced countries. I worked previously for Medecins sans Frontieres and my original research 20 years ago focused specifically on how healthcare systems in developing countries respond to emergencies. Thus, there is a certain sense of life turning full circle as I begin to think again today about some of these problems.

What do you feel poses the greatest threat to patients in ICUs?

Oh, well there are a number of threats.

First, patients can be at risk of death or injury by not being admitted to an ICU in a timely fashion. Thus, efforts at earlier identification remain a big priority in my mind.

Second, once admitted, patients can be at risk due to variability in care. I wish all ICUs delivered consistent care 24 hours per day, but they don't. Extending that notion, there has been a big focus in the last ten years on error reduction. When I think of errors, I consider both errors of omission and errors of commission. Most interest has focused on commission – actively harming a patient. However, I feel errors of omission are far more common, much more insidious, and harder to eliminate.

Third, patients can be at risk of receiving care they don't wish for – helping patients and families consider their preferences and then respecting them remains a huge challenge.

Finally, a big risk to patients' well-being in the ICU is going to be our ability to safeguard the ICU workforce. ICU clinicians can burnout, and this burnout can be a huge tax on the system. I expect patients will benefit considerably if we can effectively minimise burnout in our workforce.

What do you see as your role as chairman?

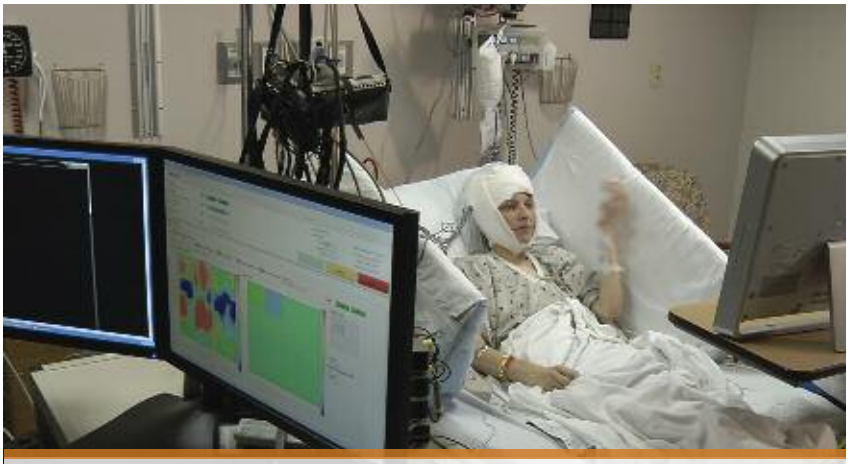
Well I wear many hats. I've been fortunate to work with a number of world-class intensive care professionals in my department. My job is to help them keep being successful. I also think I'm responsible for maintaining a vision about the future of critical care and then helping our team focus on that vision. I've spoken already about our research group. We have other research groups in the department as well, most notably the Safar Center, run by Pat Kochanek. My role with the Safar Center is to try to help Pat get what he needs and then get out of the way! Our educational programme also has fabulous leadership under Paul Rogers, and here too my job is to try to make his life easier and then let him run with things. On the clinical side, we have a whole team of ICU directors who run all of the ICUs. These folks are incredibly important. I think about ways to develop their leadership skills because I believe the ICU director inevitably has a huge role to play as a team leader to motivate staff, change outcomes and positively influence the entire hospital environment. In fact, we've just finished putting together a 15-credit certificate programme with the Department of Health Policy and Management in our Graduate School of Public Health. It is specifically designed to teach hospital-based physician leadership and we hope will eventually become a core competency for any ICU director.

How do you teach leadership?

Good question! In the case of this new certificate programme, we have created a number of specially designed courses combined with existing courses from our business school and from our degree programmes in health administration and health policy. There a number of things that one needs to learn outside of medical education in order to manage an ICU or a department. For example, it is important to know how the hospital runs with regards to hospital finance and purchasing, so that you can speak intelligently with hospital administrators. You also require basic management skills such as negotiating skills, the ability to initiate change and, of course, the ability to motivate people both by giving positive and negative feedback. Of course, a lot of leadership is innate, but many of these skills need to be practiced and honed. Even people who have some of these basic skills and are already good mentors or leaders can enhance their skills and become the best mentors or leaders they can be. This principle is the same basis for business degrees, like MBAs – there are skills that can be taught. Unfortunately, none of these skills is taught in medical school. In fact, if anything, these leadership instincts are often beaten out of you…

So, we are very interested in taking these clinician leaders who make their way into ICU director positions and work out what additional skills they can learn through didactic teaching to compliment whatever natural or innate skills they already have.

> *"…the ICU director inevitably has a huge role to play as a team leader to motivate staff, change outcomes and positively influence the entire hospital environment."*



New Pitt Project uses brain computer interfaces for people with spinal cord injury *(Courtesy of www.upmc.com)*

We are just launching this credit programme, but we have already had a great deal of success over the past two years with another programme – regular 'leadership retreats'. These are one-day courses off-campus facilitated by a professional facilitator that are attended by a group of our senior leaders. The group works together to problem-solve, engage in conflict management, build team camaraderie and leadership, and help identify potential problems and work out how to help each member function better as a team. It is a good exercise to help all ICU directors from across an entire hospital system work together, and then to help them to operate more effectively in their own ICU.

What kind of feedback have you received from this leadership retreat programme?

Well, before each course, the initial feedback is usually that most people do not want to go and question why we are making them participate… Usually ICU directors feel as though they are too busy to "waste time". Generally, though, once people are there, the mood changes and they get into the activities, often becoming quite vocal. By the end of the retreat, most actually give very positive feedback about the day and feel that it was a worthwhile experience.

> *"I have a lot of optimism for critical care as a profession so long as we continue to embrace these new models and avoid the burnout that results from the old idea that you must be chained to the unit."*

This interview will be part of the Airway issue, which features topics varying from oral care lowering instances of VAP to the effectiveness of CT scans in ARDS diagnosis. What do you see as a priority in this regard – investing in new tools or a resurgence of emphasising basic care?

I am a big fan of doing the simple things well. I think we get a lot of bang for the buck with things such as simple VAP and lung protection strategies. In the current era of sweeping waves of H1N1, there is also a basic need to make sure that the sickest patients are triaged early to the right care setting such that they are cared for by those who are best suited to handle sick patients.

Do you have any words of wisdom to impart to those entering the field?

I wholeheartedly endorse the decision to enter this specialised profession: it is a great move. I think critical care is a fantastic field, although I would caution newcomers to pace themselves somewhat. Many of us these days are adjusting to a "shift-work model" where it is important that you retain continuity of care for the patient but it is also important that at the end of a hard day you go home. There is a renewed emphasis in the field on the need for a good home life / work balance. This work we do can be intense and rewarding, but still necessitates a life outside- you should still go see a movie and enjoy off time, and a regular life. That idea has worked well for us here, knowing that you have a colleague to arrive and take the beeper from you, letting you walk away to relax and recharge from the stress of the environment. I have a lot of optimism for critical care as a profession so long as we continue to embrace these new models and avoid the burnout that results from the old idea that you must be chained to the unit. Right-sizing the workload and improving the life / work balance will certainly make the profession more attractive to prospective physicians.

So what hours do you generally work?

Me personally? I'm always on! Unfortunately the buck stops with me… Of course, I have an administrative role, a research role, a clinical role, a teaching role but I try to incorporate myself into these roles as much as possible. I try to wear jeans whenever I can and, when not in the unit or attending meetings, it is nice to have a good study to work on at home …

That does not sound like a good life / work balance!

(laughs) True, well… I'm too old to change probably. However, I try to only do research and tasks I really enjoy when I'm at home and I leave the administrative work at the office. It is the one rule I try to follow: Only rewarding work at home! ■

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BRIDGING THE GAP BETWEEN THEORY AND PRACTICE

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Publication and distribution of guidelines alone insufficiently succeed in changing practice. This theory-practice gap is, at least partly, responsible for suboptimal patient care and potential patient harm. This paper reviews the most elementary conditions to enhance successful implementation of evidence-based guidelines in daily practice.

Introduction

For centuries, man has tried to find ways to improve practice. High-quality research was found to be key. In the 1980s, the evidence-based medicine movement emerged and has firmly developed in the following decades. The emphasis was on integrating "best practice care derived from well-conducted research" taking into account the preferences of the patient, experiences of the caregiver, and ethical considerations. Since that time, vast investments in healthcare research have been made. Yet, in recent years, it has become clear that the bottleneck that exists is not due to the provision of guidelines, but rather in their implementation. This paper discusses the troublesome theory-practice gap, which is often responsible for inferior patient care. The guidelines to prevent respiratory infections are used by means of an example. Respiratory infections carry a highly relevant clinical and economic burden. Successful implementation of prevention guidelines should be of particular concern for those involved in ICU management. The recommendations provided below are nevertheless also valid for all circumstances in which implementation proves to be a hurdle.

The Theory-Practice Gap in the Prevention of Ventilator-Associated Pneumonia (VAP)

Several studies indicate that evidence-based guidelines to prevent VAP are poorly adopted. Self-reported non-adherence rates to evidence-based guidelines among ICU physicians and nurses demonstrated to be 37% and 22%, respectively (Rello et al. 2002; Ricart et al. 2003). In a multicentre survey among respiratory therapists and ICU nurses, the average reported adherence to ineffective and equivocal interventions was about 70% (Kaynar et al. 2007). In spite of this, there is growing evidence that an increase in adherence to evidence-based guidelines goes along with a decrease of VAP rates (Bird et al. 2010; Zaydfudim et al. 2009). Yet, the simple publication of prevention guidelines does not guarantee adherence. It seems that a more pro-active approach of implementation is needed to achieve favorable adherence rates.

Reasons for Non-Compliance with Guidelines

Self-reported reasons for non-compliance include inadequate resources, high costs, patient discomfort, and disagreement with the interpretation of clinical trial results (Rello et al. 2002; Ricart et al. 2003). According to a systematic review, the most frequently identified obstacles are a lack of awareness of the problem, lack of familiarity with the guideline, non-agreement with the recommendations, poor self-efficacy, inability to overcome the inertia of previous practice, and presence of external barriers to perform recommendations (Cabana et al. 1999). Yet, these results are not generalisable because barriers in one setting may not be present in another.

How to Bridge the Theory-Practice Gap?

Luckily, a number of facilitators to guideline implementation have been identified and should be considered. These refer to features of the guideline (scientific basis, logical and attractive presentation); the target group (level of knowledge, skills and attitudes, working practices); the social context (actual operating culture, views of opinion leaders), and the organisational context (organisational aspects, staffing levels).

A duly considered implementation programme includes the following elements: First, one should identify and measure the problem. This will increase awareness of the issue and convince non-believers that there is actually a problem.

Second, an action plan must be defined. This includes the selection of action points by all stakeholders: policymakers, patients and public, professional organisations and educational bodies, healthcare providers, and purchasers (Haines & Jones, 1994). It can be recommended to invite an opinion leader to support the programme.

As a third step, objectives must be defined. These should be realistic, clear and limited in order not to demotivate.

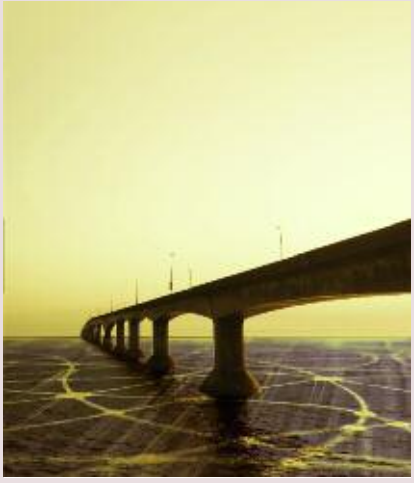
Fourth, consensus should be reached among the team members about the action plan and the way to achieve these objectives. It is important that this is negotiated prior to the implementation phase. Without consensus, the programme is a priori doomed to fail, if not on short term, definitely on the long term.

The fifth rule is to implement the programme in a multifaceted approach. Doing so will avoid a bulldozer effect which will evoke resistance. This method succeeds in enhancing awareness and behaviour towards the problem (Bouadma et al. 2010; Gross et al. 2001).

Finally, the process as well as the outcome must be monitored. Monitoring the process is done by measuring the compliance rate with local recommendations. The outcome is monitored by measuring the occurrence rate of the event to be prevented. Feedback of these data to the personnel is of key importance. Even when objectives are not achieved, feedback should be as positive as possible. If necessary, the programme must be adapted or the objectives redefined.

Knowledge as a "conditio sine qua non" to Improve Adherence

How can we expect healthcare workers to adhere with guidelines if they lack knowledge or deeper insights in the rationale of prevention measures? Targeted education is key to increasing awareness of the problem and the necessary knowledge to tackle it. Knowledge does not guarantee adherence, but it is highly important to realise that a lack of knowledge, per definition, impedes adherence. Certainly achieving long-term effects without a solid knowledge base seems to be an impossible goal. Several studies demonstrated that knowledge among European ICU nurses concerning infection prevention guidelines is poor (Labeau et al. 2010). As a response to these disappointing findings an interactive web-based 'crash course' in infection prevention is developed (www.evidenceproject.org). The interactive course design might be helpful to more easily adopt and maintain knowledge about infection prevention in the ICU. To which extent this learning module is effective, is currently a matter of study.



Conclusion

The theory-practice gap is highly relevant as it endangers patient safety. High adherence rates to guidelines are difficult to achieve. Implementation programs should be well thought-out and should take into account features of the target group, the social and organisational context. Investments in knowledge are of key importance, not only to help healthcare workers understand the rationale of the guidelines, but also because they positively affect their awareness and attitude. ■

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SWEDISH HEALTHCARE: OVERVIEW OF THE HEALTH SYSTEM

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Providing healthcare for just under 9.5 million people (www.scb.se), the Swedish national healthcare system is regularly ranked as one of the best in the world and continues to improve through innovative solutions and investment in the latest technology.

Statistics:

Total Population:
9,078,000

Life Expectancy at Birth:
m/f (years) 79/83

Healthy life expectancy at birth
m/f (years, 2003) 72/75

Probability of dying under five
(per 1 000 live births) 4

Total expenditure on health per capita
(Intl $, 2006) 3119

Number of doctors within public care per 1,000 inhabitants: 6480
(www.forsakringskassan.se)

Further information:
The Swedish Intensive Care registry (Svenska intensivvårdsregistret - SIR) is the national health registry committed to the follow up of Intensive Care and furthering knowledge in this field by using patient data from as many of Sweden´s 88 Intensive Care Units. In 2008, 70 units were members in the registry.
www.icuregswe.org
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Scandinavian Society of Anaesthesiology and Intensive Care Medicine (SSAI)
www.ssai.info

Sources:
World Health Statistics 2008
Figures are for 2006 unless indicated.

Health in Sweden

Sweden boasts high life expectancy rates – 79 years for men and 83 years for women, high cancer survival rates, as well as one of the lowest infant mortality rates in Europe, with an average of 3 death per 100, 000 children born (2008). It has the EU's highest rate of physicians per capita, at 3.3 per 1,000, which allows patients to have quick and easy access to healthcare professionals and a well-established and efficient preventative healthcare service. Compared to many other EU member states, Sweden also has a very high rate of efficiency in healthcare service delivery, despite restrictions in state funding and investment. However, like many other industrialised countries, Sweden also has a low fertility rate, which has resulted in negative natural population growth since the late 1990s, although real population growth is on the rise due to positive net migration into Sweden. Today, Sweden has one of the world's oldest populations, with more than 17% of the population being aged 65 years or older and 5.2% aged 85 years or older. Although mortality due to diseases of the circulatory system has been significantly reduced during the last 30 years, this remains the leading cause of mortality, accounting for over a third of all deaths. Chronic diseases that require monitoring and treatment and often life-long medication also place great demands on the healthcare system. One positive fact is that Sweden has relatively few smokers – almost 85 percent of Swedes are non-smokers, which is reflected in the low rates of certain smoking related cancers.

Managing National Healthcare

In Sweden there are three independent governmental levels, which are elected every four years – the national government (Riksdag), the county councils (Landsting) and the municipalities (Kommuner) – and all three are involved in healthcare. Health policy in Sweden is a national-level responsibility, however it is a highly decentralised system, which is based on three simple principles: Equal access, care based on need, and cost effectiveness.

The Swedish healthcare system is organised into seven sections: Proximity or close-to-home care (this covers clinics for primary care, maternity care, out-patient mental healthcare etc.), emergency services, elective care, hospitalisation, out-patient care, specialist treatment and dental care. The national system is administered by 21 councils, of which 18 are at the county level and three are regional. The population in these 21 areas ranges from 60,000 to 1,900,000. The 21 councils are responsible for hospitals and GPs, while the 290 municipalities provide municipal care through smaller clinics, nursing homes and home care services. There is no hierarchical relation between municipalities, county councils and regions, since all have their own self-governing local authorities with responsibility for different activities. The councils and the municipalities have considerable freedom in planning for the delivery of care, which is one explanation for regional variations.

Services Provided

Sweden has 60 hospitals that provide specialist care, with emergency services 24 hours a day. Eight of these are regional hospitals where highly specialised care is offered and where most of the teaching and research is based. The eight regional hospitals are located in Sweden's six healthcare regions, which are coordinated by the Committee for National Specialised Medical Care (Rikssjukvårdsnämnden) within the National Board of Health and Welfare.

The new Karolinska University Hospital is the largest hospital in Sweden with about 15,000 employees and 1,600 patient beds and is the result of a 2004 merger between the former Huddinge University Hospital (Huddinge Universitetssjukhus), south of Stockholm, and the Karolinska Hospital (Karolinska Sjukhuset) in Solna, north of Stockholm. It is associated with the Karolinska Institutet (KI), one of Europe's largest medical universities and Sweden's largest centre for medical training and research.

The counties own all the emergency hospitals and whilst specialised treatment is usually provided by the regional hospital service, healthcare services can also be outsourced to contractors. Usually either an executive board or an elected hospital board at the county level determines the management structure of hospitals within each county. County councils also have similar authority over primary healthcare centres, which differ from hospitals in that they are responsible for providing most outpatient care.

Municipal governments are left with the responsibility of overseeing patients who have been discharged from a hospital and need public nursing homes or home care. Although municipal authorities have a smaller role to play, it is becoming increasingly important with an aging population.

Private Healthcare

In Sweden, the county councils and municipalities are the main providers of healthcare with only about ten percent of health services delivered by private providers. Private funding, beyond user fees, therefore only plays a small role in Swedish healthcare. In 2007, less than 3 percent of the Swedish population had supplementary health insurance, with the primary benefit being the ability to avoid long waiting lists for treatment. However, private insurance has risen by 50 percent from 2004 to 2007 as Swedish hospitals are now permitted to operate at a profit and Swedish companies begin to offer employees private health insurance policies.

Financing the System

Over the past 20 years Sweden has had an average annual investment of around 9.2 percent of its GDP on healthcare. Most of the public financing comes from county council taxes (proportional income tax), which accounts for just over 70 percent of the healthcare costs. Health services for the elderly and disabled provided at home or in special residential settings are financed mainly by municipal (local) taxes. National subsidies cover approximately 20 percent of the costs.

Patient fees (out-of-pocket) account for approximately three percent of the total healthcare costs. The out-of-pocket fees for physician visits (including primary care) and for most visits to other providers are set by the individual county council, however, there are uniform national ceilings on the total amount that a patient pays during a 12-month period. Health services for children and adolescents up to 19 year of age are free of charge.

Patients also pay part of the pharmaceutical costs but an out-of-pocket ceiling also applies to pharmaceutical costs. All Swedish pharmacies are interconnected with a nationwide network, which means prescription drugs can be picked up from any pharmacy in the country.

Another service incorporated into the social welfare system is sickness pay. When a physician declares a patient to be ill (by signing a certificate of illness/unfitness), the patient is paid a percentage of their normal daily wage from the second day. For the first 14 days, the employer is required to pay this wage, and after that the state pays the wage until the patient is declared fit. The state also reimburses patients for travel costs to and from the clinic or hospital.

Healthcare Reform

The Swedish healthcare system has undergone a number of reforms and changes but, in general, the basic structure of the system has been relatively stable. The major reforms since 1970 have been result of demographic changes, with increasingly ageing population and increases in the number of people with complex non-communicable diseases. One of the main changes in healthcare and social services came in 1992 when responsibility for elderly care was transferred from county councils to local authorities (municipalities). Since hospital treatment is more costly, the aim was to care for elderly persons as far as possible in their own homes or in settings within primary healthcare. Since 1995 the municipalities have also taken over the responsibility for persons with long-term mental illness and all kinds of disabilities. Over the last decade, GP visits have steadily grown while specialist interventions have fallen. Sweden has also sought to drive patients more quickly through the hospital system, which has allowed more investment into community services and primary healthcare.

Since 2003 Swedes have enjoyed free choice in healthcare, which has allowed patients to choose to be treated at any facility in the country, under the same conditions as in their home county. By January 2010, all county councils adopted what is known as the primary choice system in primary care, which allows patients to choose whether they would prefer to go to a private or public health centre.

Specialist Projects

In June 2009, Sweden saw successful deployment of the first stage of the Swedish National Patient Summary Project (NPO). The Örebro County Council and the Municipality of Örebro healthcare region in central Sweden have connected to the NPO in the first stage of a project to create a Swedish national health record. The NPO solution, which has been extended to more than 500 doctors, nurses and occupational therapists, makes real-time patient information available on a national level to county councils, local authorities and private healthcare providers. The project was temporarily suspended, following concerns about the amount of information patients are receiving but was resumed at the end of 2010 and has been extended nationwide. Sweden is currently developing online access to electronic medical records by patients.

1177: This number is known in Swedish as Sjukvårdsrådgivningen - the healthcare advice line, for non-emergency health advice. It connects patients with a qualified nurse who has received training in telephone-based healthcare. The service is available 24 hours a day, 7 days a week. ■

PREHOSPITAL AND DISASTER MEDICINE CENTRE:

A CENTRE FOR PLANNING, TRAINING AND MANAGEMENT OF MAJOR INCIDENTS

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Major incidents can be mitigated and managed through planning, training and effective coordination of available resources. These tasks may be performed by different institutions/organisations or by only one centre. Following a national tragedy in 1998 that caused 63 deaths and over 200 casualties, a medical disaster response centre was created in Gothenburg, Sweden. The tasks for this centre were to coordinate risk assessments, disaster planning and training of staff within the region but also to act as "gold control," i.e. to take immediate strategic command over all medical resources within the region if needed.

Deficiencies in comprehension, coordination, communication and a jointly trained organisation have been recognised as important factors in a failure to respond properly to major incidents. In order to cope with quantitative and qualitative implications of a disaster, basic healthcare infrastructure needs to be expanded and adapted. Involved organisations must be coordinated to follow a pre-defined response plan, including command and control systems and support functions to overcome all substantial challenges presented at the scene. Thus, a distinct governing body is desirable to improve the delivery of aid, to maximise resources, to tune up disaster response and reduce mortality (Johnson et al. 1999; Arnold et al. 2002; Epley et al. 2006; Lee et al. 2006; Militello et al. 2007; Wenzel 2007).

Region Västra Götaland in Sweden has over 1.5 million inhabitants, Scandinavians largest port (Gothenburg), automotive factories, refineries, chemical and petrochemical industries, several airports, major highways, and holds regular public gatherings. This region, which also has over 200 primary healthcare centres, 10 emergency hospitals and a hospital integrated Emergency Medical Services (EMS), including Helicopter Emergency Medical Services (HEMS) has experienced numerous major incidents (Khorram-Manesh et al. 2009). The investigation following the Gothenburg disco fire, which had so many casualties in 1998, revealed certain short-comings regarding the medical response. It pointed out the need for a single regional point-of-contact (POC) as well as a command and control centre for all healthcare services within the region. This led to the establishment of the Prehospital Disaster Medicine Centre in 1999. The centre's tasks were to plan for, train for and immediately assume regional command and control in the event of major incidents (Gewalli et al. 2003; Khorram-Manesh et al. 2009). The premises, which were originally designed as a training facility for software applications, were physically rebuilt to serve as a command post over days and weeks with secure communications, back-up generators, white boards, computers, etc. A reserve central for ambulance dispatch was also installed within the building. All staff was trained to handle support functions within the command and control centre.

A system with a duty officer (RTiB) (RN, with specialised training in disaster medicine as well as in-depth knowledge about all the available regional medical resources) and a back-up physician on call (RBL; senior surgeon/anaesthesiologist with training in disaster medicine) was created. In this 24/7 system, the RTiB is the POC for all healthcare facilities within the region and has the mandate to act as "Gold Control," i.e. to immediately assume strategic command.

The EMS dispatch centre is instructed to page the RTiB in the following instances:

1. Three or more ambulances are dispatched to a single incident;
2. More than one hospital is expected to be involved;
3. There is a potential threat may cause multiple casualties; and
4. Other authorities/emergency services request contact.

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The RTiB should respond within five minutes after being paged and the RBL within 15 minutes. In cases of major incidents, other employees at the centre will be called to work as staff members. Specialists in other fields (e.g. CBRNe: Chemical Biological Radioactive Nuclear and Explosives) could be summoned to the centre when needed. All data are recorded in a web-based log (Khorram-Manesh et al. 2009).

A three-year follow up of this registry in 2009 showed over 1100 alerts being handled by the centre, producing over 6000 interventions, of which the majority was regional. However, the centre had also international activities by taking part in crisis such as South-East Asian Tsunami. In addition, the centre was the initiator of 28 large-scale exercises and offered over 145 courses in disaster- and emergency medicine such as Major Incident Medical Management and Support (MIMMS™) in association with Advanced Life Support Group (Khorram-Manesh et al. 2009). An increased number of hospital-related alerts during the study period raised concerns due to its negative impact on preparedness ("surge capacity") for medical emergencies as well as major incidents. This has been reported by other investigators, but seems to be a new and emerging problem for Sweden (Kaji et al. 2007; Fatovich et al. 2003; Sun et al. 2006). The reduction of hospital beds as a consequence of economic constraint, increased sub-specialisation of hospitals as well as increased dependency on high-tech equipment were among factors contributing to this problem, making the whole healthcare system more vulnerable in case of major incidents (Khorram-Manesh et al. 2009). During the study period, the number of local incidents decreased in favour of national and international incidents, emphasising the permanent need for cross-border cooperation based on common language and education; one of the main reasons for PKMC's (Prehospital KatastrofMedicinskt Centrum / Prehospital Disaster Medicine Centre) international cooperation with ALSG: Advanced Life Support Group, UK.

The high number of measures and contacts taken during these interventions demonstrate the need for communication and coordination. To assert perfect and desirable ground for communication and coordination with other agencies e.g. Police, Fire and Rescue departments and EMS, the centre organises continuous dialog meetings. These authorities are also invited to take part in the centre's various courses in disaster and disaster-related subjects. Personal knowledge about other agencies and their staff, gained during these activities, seems to be one of the most valuable factors in enhancing collaboration when an actual major incident strikes.

Disasters are inevitable, but can be mitigated through data accumulation, planning, training, research and practice. To coordinate these tasks, regional centres with powerful authority are needed. The combination of risk assessment, disaster planning and training of staff together with operational responsibility at the time of disaster may not only reveal various shortcomings within organisations and the healthcare system, but may also prevent the disastrous outcomes and consequences of such short-comings. Similar centres with redundant power to coordinate and communicate during a disaster have been reported in the literature (Epley et al. 2006; Kaji et al. 2007). However, to the best of our knowledge few, if any, have the regional responsibility for staff training by conducting disaster and disaster-related courses and training. The involvement of the same people in both planning for emergencies and disasters, training the staff for such events as well as executing the emergency and disaster plans in real life, adds strength to the organisation. No shorter feedback loop between planning and executing can exist! ■

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ICU Management is the Official Management and Practice Journal of the International Symposium on Intensive Care and Emergency Medicine.

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Derek Angus, Bronagh Blackwood, Stijn Blot, Michael L. Cheatham, Marcelo Gama de Abreu, Patrick M. Honoré, Olivier Joannes-Boyau, Amir Khorram-Manesh, Sonia Labeau, Gavin G. Lavery, Natalia Marczewska, Nancy Njoroge, Per Örtenwall, Fiona Paul, Paolo Pelosi, Jean-Charles Preiser, Patricia R.M. Rocco, Chadwick P. Smith, Dominique Vandijck, Jean-Louis Vincent, Dirk Vogelaers

ICU MANAGEMENT IS PUBLISHED BY
MindBYTE Communications Ltd
9, Vassili Michailidi CY-3026 Limassol, Cyprus

EU REPRESENTATION OFFICE:
28, rue de la Loi, B-1040 Bruxelles, Belgium
E-mail: office@icu-management.org
Website: www.icu-management.org

PUBLISHER AND CEO
Christian Marolt c.m@icu-management.org

MEDIA CONTACT, MARKETING, ADVERTISING
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SUBSCRIPTION RATES

One year	Europe	53 Euros
	Overseas	68 Euros
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Note: Participants of the International Symposium on Intensive Care and Emergency Medicine receive a one year subscription as part of their symposium fee.

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PRODUCTION AND PRINTING
Total circulation: 7,085
ISSN = 1377-7564

REFERENCES
References cited in this journal are provided to ICU Management by the authors and are available on request at editorial@icu-management.org.

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