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### Acting Outside the Box

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The focus of our review is to describe the recent developments in the structure of the intensive care at the University Hospital Aachen (Universitätsklinikum Aachen = UKA). This process has been initialised in order to improve intensive care quality, safety and efficacy, which is an ethical, scientific, economical and social requirement for the next years. The changes in management and leadership have impacted the whole practice of intensive care resulting into measurable quality improvement. We will describe the structure including human resources, technology, organisational procedures and processes needed to achieve the goals of the strategic plan of the UKA. Beneficial effects of organisational changes in the interdisciplinary surgical intensive care unit (ICU) and interdisciplinary intermediate care unit (IMC) will be presented. The UKA is an university hospital providing medical and nursing care as well as research and teaching on highest level with about 220,000 in- and outpatients a year and about 5,500 employees and 2,700 medical students.

#### Evidence Supporting Closed Generalised Intensive Care Units

There is growing evidence supporting that dedicated ICU staff is beneficial. Several reviews have showed that high level of experience and intensive workload are producing a reduction in the length of ICU stay and mortality (Pronovost et al. 2002; Young and Birkmeyer 2000). Many studies have demonstrated that closed ICUs staffed by trained, specialised intensivists are associated with a better outcome than open ICUs (Pronovost et al. 1999; Dimick et al. 2001). We define a closed ICU as a unit that has transferred all patients to an intensive care team who directs their care – taking primary responsibility for the therapeutic plan and patients care. It is mandatory that the overall responsibility is shared with the primary surgical department for all patients admitted to the ICU.

Another important ICU-organisational aspect is whether delivery of critical care of specialised ICUs providing diagnosis-specific care for selected groups of critically ill patients is associated with clinical benefits. It was suggested that ICUs with greater diagnostic diversity are associated with worse outcome (Shortell et al. 1994). Recently, the association between specialty ICU care and the outcome of critical illness has been evaluated retrospectively analysing 84,182 patients admitted to 124 different ICUs in the US. It could be demonstrated that in this diverse large group of United States hospitals, risk-adjusted in hospital mortality did not differ between specialised and non-specialised generalised ICUs (Lott et al. 2009). Furthermore there was no difference between specialised and generalised ICUs in the length of stay. Admission of patients to a non-ideal specialty ICU, as might occur if a hospital has a limited number of specialty ICUs, was associated with significantly higher adjusted mortality.

#### ICU Outside the Box

There are several ways of extending the availability of intensivists outside the ICU box. Due to the shortage of ICU beds in the UK, critical outreach teams have been established. These teams care for ICU patients post discharge, as well as critically ill patients on general wards and on high dependency units (HDU) in order to avoid unnecessary admissions to ICU. These HDUs, or step down units are an alternative answer. In Germany, these units are usually called intermediate care units. These units provide a lower staff-to-patient ratio as the level of critical illness is

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lower compared to an ICU patient. Sometimes these units are attached to ICUs, sometimes they are attached to the general wards aiming to care for patients with a required level of support between the high level care area (ICU) and low level area (general ward). As this group of patients needs to be discharged frequently from an ICU to create a bed for an emergency case, the chance of deterioration is high when there is no safety net like an intermediate care unit available. In our institution, we have defined a set of criteria that create a basis to decide when a patient is ready for discharge from ICU to the intermediate care unit or vice versa (Figure 1).

### **ICU Concept in Aachen**

The process of organisational changes at the UKA in Aachen began in 2005. Prior to that time, intensive care medicine was provided in several specialised ICUs. The medical and neurology ICUs have been kept as specialised ICUs, and a joint venture was initiated that included all specialised surgical and the anaesthetic ICU. The change resulted in a new ICU structure – the creation of a department of interdisciplinary intensive medicine “Operative Intensivmedizin” including all surgical and trauma ICU beds. We will discuss the development process of this department further later on in this review. The new department of interdisciplinary intensive medicine “Operative Intensivmedizin” is led and organised by an ICU leader and a dedicated ICU team including anaesthetists, surgeons and nurses. The ICU leader and consultant intensivists are board certified anaesthetists, who are additionally certified in the subspecialty of intensive care medicine. They have been scheduled during daytime hours to exclusively provide clinical care in the ICU. During nighttime hours, one ICU consultant has been on call at home, with ICU residents working exclusively in the ICU.

The main feature of this concept is the interdisciplinary, patient-focused, and respectful teamwork of many healthcare providers, but most importantly between intensivists and surgeons. Intensivists and surgeons perform daily joint rounds during which therapeutic decisions are made. Furthermore, the provision of postgraduate ICU-training for all anaesthetic and surgical trainees is essential and mandatory in ICU board certification.

In 2008, the board of directors of the UKA and the medical faculty decided to further the organisation of intensive care medicine in Aachen. They established the first chair of anaesthesiology with the focus on surgical intensive care medicine. Thus, there are now two chairs of anaesthesiology in place at the UKA. The two chairmen are deputies of each other. The two separate departments share the same strategies, including staff recruitment and development, research, under- and postgraduate teaching. The academic department of interdisciplinary intensive medicine “Operative Intensivmedizin” now includes the previous 42 beds and a 6 bed burn unit has been added, as well as a research team which runs its own basic-science laboratories.

The head of department and several consultants are present during daytime hours to exclusively provide clinical care on the ICU. In order to meet the challenge of the increasing morbidity of ICU patients, one consultant intensivist is now present exclusively on the ICU during the night shift. Thus, there is continuous high-level critical care provided 24 hours a day, 7 days a week. In addition, a continual supervision of trainees and residents is guaranteed. On average, there is one resident looking after ten ICU patients and the average nurse-to-patient ratio is 1:2.5. Strategies to improve quality and patient safety have also been enhanced. An increasing number of standard operating procedures and well-defined clinical pathways have been established to ease the application of evidence-based critical care treatment. Furthermore, clearly defined responsibilities, a matrix of regular meetings, national and international benchmarking, quality assessment audits and enhanced team-communication initiatives have been introduced.

### **Intermediate Care Concept in Aachen**

In 2005, a new intermediate care concept was also established. The organisational structure at the UKA included an interdisciplinary separate Department of Intermediate Care (IMC). This structure was unique in Germany at the time. The IMC Department comprised up to 48 beds and was run by an IMC leader and a team including physicians, cardiologists, gastroenterologists, nephrologists, anaesthetists, surgeons and nurses. This team looked after all medical and surgical intermediate care patients.

In 2008, IMC divided into two separate entities: a medical unit and a surgical unit. The surgical IMC unit runs under the leadership of the head of department interdisciplinary intensive medicine “Operative Intensivmedizin” and the medical IMC unit runs under the leadership of the head of department of cardiology. Additionally structural and quality changes parallel to the department of intensive care were initiated.

Thus, the surgical unit of the department of interdisciplinary intermediate care is led and organised by an ICU leader and an IMC team including intensivists, anaesthetists, physicians, surgeons and nurses focused on the care of critically ill surgical patients. The IMC leader and consultant intensivists are board certified anaesthetists who additionally certified in the subspecialty of intensive care medicine and a consultant, who is a physician. Consultant coverage is guaranteed during daytime hours exclusively providing clinical care on the IMC. During nighttime hours, an ICU consultant is on call at home with an IMC resident being present exclusively on the IMC.

There is on average one resident looking after 12 IMC patients during the day and the average nurse-to-patient ratio is 1:4. There is one resident present exclusively on the IMC during the night shift, who is responsible for 24 patients and a consultant on call. Thus, continuity of high-level clinical care is once again provided over 24 hours, 7 days a week.

### **Comparing Surgical ICU and IMC Data Before and After the Organisational Changes**

In 2009, both the ICU and IMC departments treated more cardio- thoracic and vascular surgical patients than patients from all other surgical

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departments (Figure 1). We successfully allocated all surgical patients in our surgical ICU and IMC and could provide care for medical patients in addition (5-8% of the total number of patients).

Compared to 2008, we observed an increase in the severity of illness and morbidity in our group of ICU-patients. The case mix index on ICU increased on average by 8% from 5.97 to 6.46, in the group of more critically ill patients requiring more than 24hr ICU treatment, there was even an increase of the case mix index by 11%. Furthermore the number of patients requiring more than 24hrs of mechanical ventilation increased by 3%. This shift resulted in an increase of length of ICU stay from 4.9 to 5.4 days. Despite the substantial increase in the severity of illness in our ICU patients, we could reduce the mortality in the patients requiring more than 24 hrs of mechanical ventilation from 25.5% in 2008 to 23.3% in 2009 (Figure 2). This outcome improvement may be in part due to the organisational changes and several quality improvement initiatives. The average cost of an ICU bed in 2009 was euro 1146 (Figure 3).

After reorganisation of the surgical IMC, more patients could be admitted to this unit. There was a total increase in the number of treated patients of 21% in 2009 compared to 2008 (Figure 7). Analysing the data there was an increase of 53% in the group of patients requiring IMC up to 24 hrs and of 3% in patients who needed the IMC more than 24 hrs (Figure 4). This large increase of treated patients was possible because we could reduce the length of stay by 18%. The reduction in the length of stay occurred despite an increase in the severity of illness in the IMC patients. The case mix index on IMC increased on average by 4% from 5.2 to 5.5, in the group of patients requiring more than 24hrs of IMC treatment, there was an increase of the case mix index by 16% from 6.3 to 7.3. The associated mortality of IMC patients decreased from 1.6% in 2008 to 1.1% in 2009.

The distribution of patients changed substantially after the organisational changes. There was an increase of surgical patients from 1273 patients in 2008 to 1926 patients in 2009 (+51%) associated with a decrease of medical patients from 462 in 2008 to 165 in 2009 (- 64%) (Figure 5).

Clearly the organisational changes enabled a substantial higher number of admissions, hence increasing the number of performed surgical procedures in the OR.

The total cost of an IMC bed/day was euro 637. Comparing the cost between ICU an IMC we could identify more staff, drugs and devices required on the ICU to maintain the higher level of care as an explanation of the higher cost (Figure 3).

#### **Advantages of the Aachen Concept of Surgical Intensive Care Medicine and Intermediate Care**

After examination of the positive results after the organisational changes of the interdisciplinary surgical ICU and interdisciplinary surgical intermediate care unit (especially between 2008 and 2009), there are several issues to be considered.

The structure is based on an effective leadership which has built a caring ICU team including more than 40 intensivists, and more than 140 nurses, physiotherapists and other staff, including a case manager who enables the timely transfer of patients to rehabilitation facilities. The size of the departments requires clear defined objectives, planning, organising, monitoring and communication to build and maintain a dedicated team, while also allowing for a wide flexibility to balance personalities, skills and talents. This team is able to provide a continuity of intensive care on an experienced consultant level, which is associated with better ICU-outcome. The established staffing model furthers the interdisciplinary ICU team approach to critically ill patients with improved timely patient evaluation and therapeutic decisions and additionally enhanced communication and collaboration with all surgical departments. In addition, it is important to respect the traditional structure between medical and surgical/trauma ICU patients.

The focus on improvement of quality, safety (e.g. same equipment at all ICU beds) and risk reduction has resulted in robust standardised care at the bedside combined with ICU expertise to add individualised care whenever required. In addition, an emphasis on teaching has improved postgraduate training, which is also important for the motivation of the trainees and beneficial for the patient. The early diagnosis of severe sepsis in IMC is a good example of the benefits of this improved level of care. We have observed several severe septic patients on IMC receiving early, standardised sepsis bundle treatment according to the Surviving Sepsis Campaign, thereby improving very rapidly and consequently avoiding ICU admission. The enhanced training and research activities have also proven to be an attraction for new members of staff.

Clear defined responsibilities and clinical pathways in IMC have resulted in improved processes, for example, the reliability of the OR-schedule or admission of an emergency patient. The improved process of ICU discharge and post ICU care is another important area. Due to the improved cooperation between ICU and IMC teams, delayed ICU discharges could be reduced. This is very important, as an increase of ICU length of stay is associated with increased risk of nosocomial infection, increased costs, lower efficiency of resources and the threat of ICU bed shortages (Zimmerman et al. 1996). On the other hand, early discharge of ICU patients will result in readmissions and increased risk of prolonged ICU stay and mortality. Thus, the improvement of interfacing issues between ICU, IMC, OR and general ward has been key in the success.

#### **Future Directions and Challenges**

In general, the major task of intensive care medicine is to improve the quality of care continuously, by preserving human life and providing suitable rehabilitation as soon the patient starts to recover. In addition, it is essential to provide adequate palliative care and support for family and patients in the end of life situation.

At the University Hospital Aachen we have the vision to establish a centre of excellence for ICU within the heart of Europe. Therefore, we feel the integration of surgical intensive and intermediate care departments into one joint department is the next major step to improve quality, safety, flexibility and availability of ICU bed capacity for elective and emergency surgical patients. The development of the team and structure will be continued. Soon we will introduce psychological support for patients, relatives and staff including supervision for the team. A continuous benchmarking on regional, national, international is obligatory to ensure transparent quality assessment, safety and economical value. Finally, another major step towards our vision is the planned joint venture with the "Akademisch Ziekenhuis Maastricht" (AZM) in the Netherlands, in order to establish the first joint European University Hospital.

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