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Abstracts

The senior author of each article has confirmed that the ethical aspects of these studies have been approved (a) for clinical studies by the Institution or an Ethics Committee and, if applicable, that informed patient consent has been obtained, (b) for experimental studies, involving the use of animals, by the institution and that the animals have been treated according to good practice.

Meeting of the Society in Europe for Simulation Applied to Medicine (SESAM), 10–11 May 2002: Santander, Spain

SANTANDER-02-01

The usefulness of simulator training in combination with psychological training sessions for the improvement of non-technical skills

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Good management of medical crises requires non-technical skills like communication, team co-operation, planning, etc. In current medical training these competencies are not systematically being trained. Simulator trainings of crisis management use psychological knowledge for the improvement of non-technical skills.

Objective: To evaluate the usefulness of simulator training in combination with psychological training modules for the improvement of soft skills. The first module is 'communication and team co-operation'. Here, first results of the evaluation are given. 'Mental models' is the next module to follow.

Methods: 34 anaesthetists (1 to 4 yr experience in anaesthesia) took part in either a 2 h training session on team co-operation and co-ordination (treatment, $n = 20$) or heard a talk on human factors in the operating room (OR) (control, $n = 14$). All subjects then performed one out of three simulator scenarios with specific requirements of team co-ordination and communication. Having obtained informed consent, the simulator sessions were video-taped. Subjects answered an evaluation questionnaire immediately after the course and were interviewed 4 weeks later about behavioural changes in the OR and memory of the course. The video tapes were analysed on three levels: behavioural markers for the quality of communication and team co-ordination, a protocol system for action regulation and problem solving, and two medical experts' assessment of the medical management.

Results: The relevance of communication and team coordination in the OR is highlighted by the correlation between medical management scores and behavioural markers ($r = 0.56$). The need for recurrent training in these domains is emphasized by most participants in the follow-up interviews. The simulator course is evaluated by both groups as interesting, relevant, and challenging. Significant differences between the groups: The treatment group (communication training) remembers more of the training than the control group. Relevance and practicability of the course are rated higher. For the treatment group the scenario was more stressful, due to the attention they gave to communication and team processes. Participants of the training group report 4–8 weeks later more changes in their team behaviour and in self-reflection than those of the control group. They draw more personal conclusions and give more specific 'lessons learned'. Analysis of behavioural data show significant differences between training and control group: the training group addresses the surgeon more often. They also have more conflicts with the surgeon, but the reaction to conflicts is more often problem-orientated or de-escalating or ignoring than in the control group. In the training group, more utterances refer to the process of problem-solving, and hypotheses play a stronger role.

Conclusions: The training of crisis management with simulator scenarios is evaluated as useful and practicable. Psychological training sessions are seen as important and valuable. The combination leads to significant changes in behaviour. Results indicate that time and opportunity for practising new behaviour is needed. We conclude that soft skills should not only be trained in crisis scenarios but also in the real OR and perhaps in special training sessions outside the simulator.

SANTANDER-02-02

How effective is simulator-based training of emergency care in UK general practitioners?

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Simulator-based training in emergency care is well established within UK hospital specialties. The impact of this form of training among general practitioners (GPs) has not been reported.

Objective: To evaluate the effectiveness of simulator-based training in emergency care among UK GPs.

Methods: A cohort of GP registrars ($n = 11$) from the Guildford vocational training scheme participated in a day's training in emergency care at the Chelsea and Westminster Resuscitation Simulator Unit, UK. Participants were asked, at the beginning and at the end of the day, to rate, on a five point Likert scale, the extent to which they agreed with 11 items in a validated self-reporting questionnaire.

Results: Completed questionnaires were received from 10 participants. Initial mean scores were highest for valuing feedback (mean 4.8, SD 0.41) and recognising acute situations (mean 4.4, SD 0.81) and lowest for knowledge (mean 2.3, SD 0.79) and confidence (mean 2.7, SD 1.1). Before and after mean differences for each questionnaire item were analysed using paired t-tests. Marked improvements in confidence (t −3.464, P 0.006), knowledge (t −4.892, P 0.001), skills (t −2.667, P 0.024) and valuing being videoed (t −3.317, P 0.008) were noted. No significant changes were seen in terms of own performance (t −1.174, P 0.267) or clinical experience (t −1.456, P 0.176).

Conclusions: These initial findings among a small cohort of GP registrars suggest that simulator based training, over a single day, may significantly improve knowledge, skills and confidence of participants in emergency care as well as enhance willingness to undertake critical review of professional standards. It is hoped that the participants continue developing an approach to incorporating the concepts, which they are exposed to on this day, into their daily clinical activities and practice. The potential for simulator training to directly impact on care of critically ill patients in the community is an exciting development for all Primary Care Organisations.

SANTANDER-02-03

Using a high fidelity patient simulator for training dentists in crisis management

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Based on David Buckley's lecture at the 2000 annual meeting of the Society of European Simulators Applied to Medicine in Mainz, and Girdler's paper on Resuscitation, the Santander Simulation Centre has developed a half-day course for training dentists in crisis management using a high fidelity patient simulator [1,2]. Medical emergencies arising in dental practice are generally perceived as being uncommon. However, when an emergency does occur it can be life-threatening. No dental procedure can ever take priority over a patient's life and thus, it is really important for dentists to be able to recognize and initiate first responses to emergencies. The ability of the dentist to initiate primary management is the key to minimizing morbidity and mortality. The aim of the courses is to train dentists as first responders in crisis management in both human factors and medical aspects of the crisis. One objective is to provide guidelines as to which emergency drugs and equipment should be stocked in dentistry. The course is designed for six participants. The structure of the course is shown in Table 1.

Results: Between January 2001 and March 2002 we have held 12 courses (72 participants). All participants filled in a questionnaire at the end of the course (rating scale 1 to 5; 1 minimum, 5 maximum). The results are shown in Table 2.

Conclusions: There is a need for dentists to train and to learn how to recognize and manage medical emergencies. These courses should be recognized for continuing medical education in dental practice, as the British General Dental Council guidelines

Table 1. Crisis management course structure.

08:00–08:15	Introduction
08:15–09:15	Behaviour and skills for managing medical crisis
09:15–11:15	Protocols for treating most frequent events in dental practice (vasovagal syncope, hypoglycaemia, angina, epileptic fit, anaphylaxis and cardiac arrest)
11:15–12:00	Airway management workshop
12:00–14:00	Clinical scenarios and debriefing sessions (vasovagal syncope, hypoglycaemia, angina, epileptic fit, anaphylaxis and cardiac arrest)
14:00–14:15	Assessment and farewell

Table 2. Course questionnaire results.

Questions	Score
Has the course been useful for your job?	4.89 ± 0.8
Do you think the schedule is suitable?	4.78 ± 0.4
Have you got set goals for this course?	4.73 ± 0.8
Have these objectives been achieved?	4.85 ± 0.31
Has the course improved your skills in airway management?	4.71 ± 0.3
Did the scenarios seem realistic?	4.62 ± 0.34
Would you retake the course?	100%
How often would you retake the course, if so?	12 months [6–24]

clearly state that 'resuscitation routines should be practised in a simulated emergency' [3]. High-fidelity patient simulators are a useful tool for training dentists as first responders in a medical crisis. The schedule of our programme is useful for training dentists in crisis management.

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SANTANDER-02-04

Enhancement of medical students' self-confidence on first performing general anaesthesia

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During their fourth year medical students have a 2 week course in anaesthesiology. The students are introduced to general anaesthesia by an anaesthesiologist in the operating room on a patient during routine clinical work. Our hypothesis was that an introduction using a full-scale patient simulator should give the students better self-confidence and less anxiety the first time they participated in giving a patient general anaesthesia.

Methods: Twenty-four students were randomized to be introduced the traditional way or by using a METI Human Patient Simulator (HPS). The 'simulator students', in groups of 3 or 4, had a short lecture in the cognitive loop of observation, assessment, decision making, action, and re-evaluation as applied to the anaesthetic procedure. In a scenario each student acted as anaesthetist performing a highly realistic induction, endotracheal intubation and awakening of the patient. Each student also experienced the identical sequence in the roles of the anaesthetic nurse, operating nurse, surgeon or observer. The instructor gave the student close guidance resulting in error-free anaesthesia management. The cognitive loop, communication and resource management was discussed during a debriefing session. After this introduction the 'simulator group' had the same 2 week clinical training in anaesthesia as the 'traditional group'. At the end of the 2 weeks all students answered a questionnaire. Thirteen questions focused on the student's feelings the first time he/she participated in giving general anaesthesia to a patient. Answers were given on a scale from 1 to 10. Data are given as median; the Mann-Whitney rank sum test was used as a *post hoc* test and $P < 0.05$ was considered significant.

Results: For 10 of the questions there was no significant difference between the two groups, including the question 'Were you calm when you entered the operating room?' ($P = 0.86$). The 'simulator group' had significantly higher scores than the control group for the questions 'Did you understand how and when the anaesthesia machine should be used?' (7.5 vs. 4.5, $P = 0.04$), 'Was the situation at the induction familiar to you?' (7.0 vs. 3.5, $P = 0.006$), and 'How much responsibility did you feel you had for the patient?' (6.5 vs. 3.0, $P = 0.02$).

Discussion: The 'simulator group' recognised the anaesthesia procedure in the messy anaesthetic working environment better than the 'traditional group'. This also supports the assumption that the simulator scenario was realistic. In reality the anaesthesiologist in charge has the medical responsibility for the patient, not the student. However, the 'simulator group' was prepared to shoulder more responsibility for the patient. This is probably due to more knowledge and training. Thus, we conclude that 'simulator' training enhances the student's self-confidence. An increased awareness of inherent risks in the anaesthetic procedure may explain that there was no difference regarding anxiety between the two groups.

SANTANDER-02-05

Pharmacokinetic parameter transformations for educational simulations

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Simulations developed for training of healthcare professionals typically use computerized mathematical models of human physiology and pharmacology. Educational simulations may involve many drugs and patient groups. Pharmacokinetic (PK) data in the scientific literature are presented in a wide variety of PK parameter set formats. This complicates the incorporation of PK data in a simulation model with a given structure and associated parameter format. To solve this problem, we defined three sets of independent parameters, referring as much as possible to the pharmacokinetic literature [1], and localized and/or derived the analytical relationships between them.

Methods: Figure 1 shows the names of the defined parameter sets and the transformations between them, and Tables 1 and 2 define the 'Clinical' and 'Base' sets for 2nd order PKs, respectively.

Strictly speaking, half-life is the time required for the plasma concentration to be reduced by 50%.

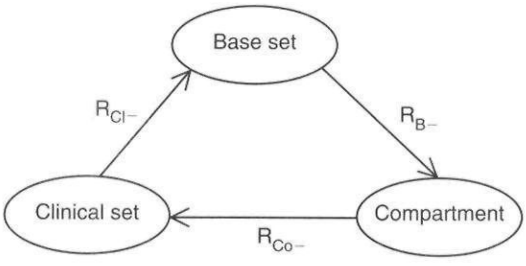

Figure 1.
Pharmacokinetic parameter sets and transformations.

Table 1. Second order clinical set.

Symbol	Typical units	Description
t_1	min	Half-time of the fast decaying exponential
t_2	min	Half-time of the slowly decaying exponential
Cl	$L\,kg^{-1}\,min^{-1}$	Total drug clearance
V_1	$L\,kg^{-1}$	Initial volume of distribution

The half-times used in the clinical set directly refer to the individual exponentials and disposition rate constants of the response to a unit bolus dose:

$$h_B(t) = \frac{1}{V_1}\sum_{i=1}^{n} A_i e^{-\lambda_i t}, \qquad \sum_{i=1}^{n} A_i = 1$$

which is the model underlying the base set. The relationships between the half-times and the disposition rate constants reflect this observation. Assuming that the plasma concentration data can be described by the parametric bolus response function we can calculate the areas under the concentration-time curve and under the first moment of the concentration time curve, respectively [1]. The parameter A_1 is derived from the clinical set based on this observation.

Results: Table 3 shows examples of derived transformations.

The complete analytical relationships between the parameter sets for first, second, and third order PKs facilitate the incorporation of diverse pharmacokinetic data in educational simulations.

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Table 2. Second order base set.

Symbol	Typical units	Description
λ_1	min^{-1}	Disposition rate constant of the fast decaying exponential
λ_2	min^{-1}	Disposition rate constant of the slowly decaying exponential
A_1	–	Relative amplitude of the fast decaying exponential
V_1	$L\,kg^{-1}$	Initial volume of distribution

Table 3. Parameter transformations from the second order clinical set to the second order base set.

$$\lambda_1 = \frac{\ln(2)}{t_1} \qquad \lambda_2 = \frac{\ln(2)}{t_2} \qquad V_1 = V_1$$

$$A_1 = \frac{-e + \sqrt{e^2 - 4df}}{2d}$$

where

$$d = -(\lambda_2 - \lambda_1)^2$$

$$e = \frac{V_1}{V_{ss}}(\lambda_2^2 - \lambda_1^2) + 2\lambda_1(\lambda_1 - \lambda_2)$$

$$f = \left(\frac{V_1}{V_{ss}} - 1\right)\lambda_1^2$$

Ciência e a Tecnologia, of the Portuguese Ministry of Science and Technology provided funds for participation in this conference.

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SANTANDER-02-06

Simulation of fetal heart rate during hypoxic stress

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Maternal hypotension following spinal anaesthesia or cardiac arrest, maternal hypoxia associated with ventilatory complications, and fetal asphyxia caused by compression of the umbilical cord are examples of critical situations in obstetrics and in anaesthesia for the pregnant woman. These incidents are often associated with a high risk to the woman and fetus. Therefore, simulation is a valuable tool in teaching the diagnostic and therapeutic skills in this context. We have described a mathematical model for the educational simulation of the oxygen delivery to the fetus [1]. Here we present a second component of our educational fetal distress simulator (FDS) generating a fetal heart rate (FHR) signal in its response to hypoxic stress.

Methods: We used an empirical approach for simulating this response (Fig. 1). The FHR signal is decoded to its individual components for clinical analysis: baseline, decelerations, heart rate variability (HRV) and accelerations. The decelerations depend directly on the partial pressure of oxygen in the fetal arterial blood, $P_{af}O_2$, an output of the presented model [1], reflecting an important component of the chemoreflex. HRV depends on a pathophysiological state variable. This qualitative variable depends on the magnitude and duration of hypoxic stress and can take on the values: Normal, suspicious, pathological, and death. The accelerations depend on the spontaneous fetal activity, which is only present with a normal pathophysiological state.

Results: Consider a situation where $P_{af}O_2$ reduces from normal values to 2.1 kPa. The chemoreflex mediates a deceleration for the duration of the fall. The pathophysiological state evolves from normal to suspicious, HRV is reduced accordingly, and accelerations disappear. Figure 2 shows a simulation of the effect of a brief maternal cardiac arrest followed by successful resuscitation.

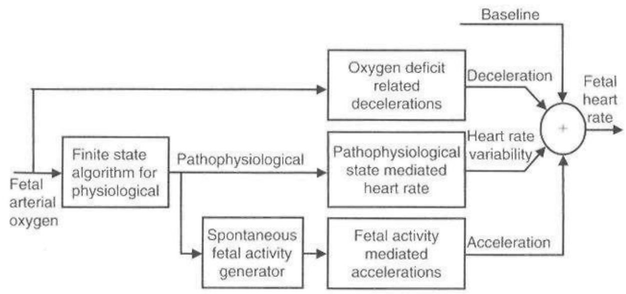

Figure 1.
Block diagram of the system for simulating the fetal heart rate response to hypoxic stress.

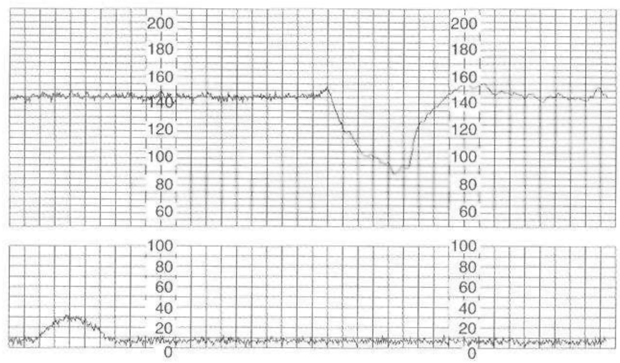

Figure 2.
FHR (beats min^{-1}) during maternal cardiac arrest. Contractions corresponding to false labour.

Conclusions: An on-going clinical validation addresses the question of whether the simulated FHR response is 'realistic enough' for educational simulations. We presented an original empirical model for educational simulation of the effect of hypoxic stress on fetal heart rate.

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SANTANDER-02-07

Graphical and mathematical representation of congenital heart disease

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The aim of this work is to represent congenital heart diseases graphically and mathematically for use in educational simulations of the neonate and infant. This work is based on a previously published model for the adult cardiovascular system [1] (Fig. 1).

Methods: A model for the term fetus [2] contains structural elements representing a patent ductus arteriosus and an open foramen ovale. These structures, as well as those necessary for the simulation of a ventricular septal defect were incorporated in the Beneken model (Fig. 2).

As an example of how the mathematical model is derived from the graphical representations, we present the equations for the patent ductus arteriosus (PDA). The flow rate trough the PDA is a new state variable:

$$\frac{dF_{da}(t)}{dt} = \frac{P_{itha}(t) - P_{pa}(t) - R_{da}F_{da}(t)}{L_{da}}$$

where $F(t)$: flow rate; $P(t)$: pressures; R: resistances; L: inertia; da: ductus arteriosus; itha: intrathoracic arteries; pa: pulmonary arteries. $F_{da}(t)$ is positive in the systemic → pulmonary direction.

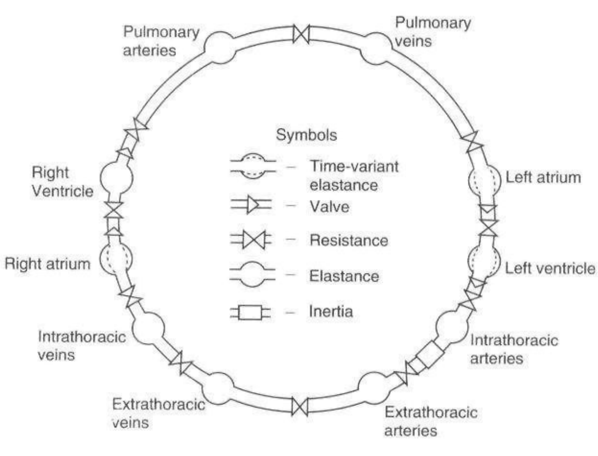

Figure 1.
Hydraulic analog of the Beneken model.

Conservation of mass in the intrathoracic and pulmonary arteries is reformulated as follows:

$$\frac{dV_{itha}(t)}{dt} = F_{lv}(t) - F_{da}(t) - F_{itha}(t)$$

$$\frac{dV_{pa}(t)}{dt} = F_{rv}(t) + F_{da}(t) - F_{pa}(t)$$

where V: volumes; lv: left ventricle; rv: right ventricle. Flow rates are compartment outflow rates.

This model was simulated with the parameters reflecting a 6-month-old infant [3].

Results: Table 1 shows preliminary simulation results with and without a moderate PDA. The relative pressure changes are similar to the ones reported for neonates in [4]. We are currently pursuing a specific reference for infants.

Acknowledgements: This work was funded in part by a grant from Medical Education Technologies, Inc., Sarasota, Florida, USA. The Fundação para a Ciência e a Tecnologia of the Portuguese Ministry of Science and Technology provided funds for participation in this conference.

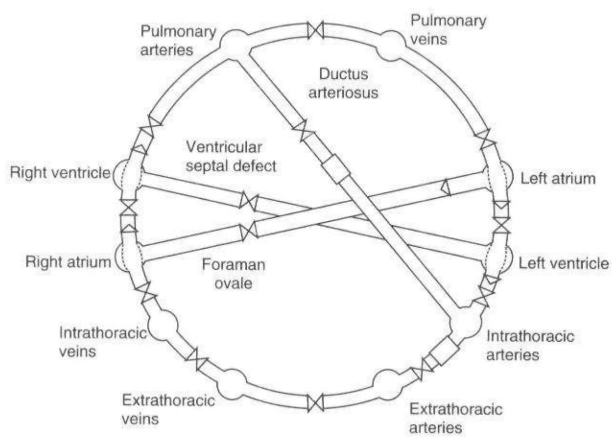

Figure 2.
Hydraulic analog of the cardiovascular model reflecting congenital heart diseases.

Table 1. Simulation results: Normal infant and an infant with a moderate PDA.

	Pressures (mmHg)					Co
	RV	LV	PA	Ao	PV	(L min^{-1})
Normal	19/3	90/3	15/6	84/55	6	1.7
PDA	29/4	82/3	25/14	73/25	10	1.1

RV: right ventricle; LV: left ventricle; PA: pulmonary arteries; Ao: aorta; PV: pulmonary veins; Co: cardiac output (from RV).

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SANTANDER-02-08

The Simulation Training Centre of the Department of Anaesthesiology of the Maria Sklodowska-Curie Memorial Cancer Centre, Warsaw, Poland

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Our Simulation Training Centre was established in January 2001, in cooperation with the Danish firm Math-Tech. The program used for simulation is the SIMA 1.1, compatible with Dameca and Datex equipment. In order to carry out simulation we use the SimMan mannequin (Laerdal), equipped with its own simulation program. The Simulation Centre is manned by two anaesthesiologists-instructors and two trained nurses, who act as operating theatre personnel during the training courses.

Training courses are aimed at medical personnel of all levels. Courses covering behaviour in case of cardiac arrest (including special techniques and advanced resuscitation equipment) are the most popular and are aimed at doctors/non-anaesthesiologists and the nursing staff.

Anaesthesiologist training deals with new equipment (e.g. for difficult airway management) and new drugs (e.g. desflurane anaesthesia). The most sophisticated simulation programmes cover such areas as circulatory, respiratory and neurologic complications, malignant hyperthermia, anaphylactic shock or hormonal crises both intraoperatively and in the ICU. The scenarios concerning difficult airway management and hormonal crises have been prepared according to the experiences of our anaesthesiologists.

Since its opening the Centre has trained 55 doctors and 400 nurses. On the completion of training special certificates are issued to the trainees. The main issues limiting the number of trainees are, besides financial problems, negative attitudes towards testing one's own knowledge/practical skills and a belief that the training is highly stressing. The effects of our research was presented at the IMMS 2001 – the paper which we presented dealt with training in the treatment of intraoperative hormonal crisis.

SANTANDER-02-09

Evaluation after training in the procedicus endoscopic simulator: a study among undergraduate medical students

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Advanced simulator training within medicine and healthcare is a rapidly growing field. Virtual Reality (VR) simulators are being introduced as cost-saving educational tools, which also leads to increased patient safety. This paper presents the findings of a study in which the use of the Procedicus KSA (Key Surgical Activities) simulator was tested as an educational tool to train medical students at Huddinge University Hospital. It is claimed that these simulators will be able to reduce educational costs, circumvent the ethics issues tied to training new surgeons on animal specimens, and improve patient safety. The improvement of patient safety is a key element in discussions stemming both from a concern for patients' well-being and a recognition that correctly performed surgical procedures are less costly for the healthcare institution. There is also speculation that VR simulators can eventually be used to introduce standardized skill evaluation.

Methods: Ten medical students (3 female, 7 male) were included in the study. Performance was monitored in 2 endoscopic simulators (Procedicus with haptic feedback and MIST without haptic feedback) before and after 1 h of training in the Procedicus simulator. Time, movement economy and total score were registered. Long-term learning curves were also analysed in one individual performing more than 300 tests.

Results: There was a significant improvement after 1 h of training regarding time, movement economy and total score. Results in the Procedicus simulator were highly correlated to performance in the Minimally Invasive Surgical Trainer (MIST) simulator. The students mentioned that they felt the value in simulator training lay in the ability to practise procedures without having to worry about injuring a real patient.

Conclusions: Our results show that the use of surgical simulators as a pedagogical tool in medical student training is encouraging. It shows rapid learning curves and emphasizes the importance of patient safety.

SANTANDER-02-10

Difficult airway – a suggestion of simulation training. Anaesthetists in practice versus ASA standards

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In cases of situations requiring fast decision making, simulation training may provide a method of testing whether practice conforms to standards. By analysing questionnaires designed to evaluate the actions of trained anaesthesiologists faced with difficult intubation situations we have discovered the need to provide simulation training for difficult airway. In the Simulation Training Centre of the Maria Sklodowska-Curie Memorial Cancer Center in Warsaw we have already held a number of courses on difficult airway management. They were designed to acquire skills with new equipment (fibreoptic intubation, Trach-Lite®). However, we have not yet held simulation training designed to assess the doctors themselves. The aim of the study was to find out whether the behaviour of anaesthesiologists in face of a difficult intubation remains in unison with ASA standards.

Twelve anaesthesia consultants employed at the Institute took part. In the simulation training room the mannequin had been arranged for a difficult airway case and a team formed by a doctor and an anaesthetic nurse was informed that it was to deal with a case of spinal injury and severe trauma to the maxillo-facial area. The patient was semiconscious, on the verge of respiratory insufficiency and being prepared for urgent laparotomy. The objective was to secure the airway as fast as possible. The equipment found in the simulation room was identical with that in an ordinary operating theatre. During the simulation programme we were able to present desaturation, tachycardia and hypotension.

In order to assess anaesthetic practice a form containing ASA standard procedures was prepared. After analysis we concluded that nobody behaved according to standards. Serious omissions included – 'call for help' – neither for another anaesthesiologist or the surgeon, no saline suction, removal of the Schantz collar, head manipulations, too long a reaction time before the decision to intubate.

None of the observed anaesthesiologists made use of additional equipment; one person decided to perform tracheostomy by himself. Some administered steroids (due to spinal trauma). One person decided to administer catecholamines. A majority forgot about Sellick's manoeuvre. None achieved 100% correct answers. A majority of trainees ended up with one or two flaws in their questionnaires, although in 30% of questionnaires replies there were at least three flaws.

The results emphasize the need to prepare an effective scenario concerning difficult intubation. Constant training in such cases is vital, as well as training anaesthesiologists in the use of additional equipment designed to secure the difficult airway.

SANTANDER-02-11

Comparison of action density patterns between simulator and clinical settings

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The question of whether simulator settings represent the salient characteristics of real work situations remains unanswered. This study aims to assess the ecological validity of simulator settings on an empirical basis by analysing action sequences across various settings. In our research on action sequences in clinical practice we focus on the ways in which complexity and unexpected events (i.e. disturbances, interruptions etc.) are handled by the anaesthetists [1].

Methods: After obtaining informed consent, 6 anaesthetists (3 first year and 3 third year residents) took part in the study. All participants were observed during 2 cases with patients and 3 simulator cases involving laparoscopic surgery. In the simulator setting the participants were exposed to 1 routine case (control scenario) followed by 1 case with acute haemorrhage and 1 with anaphylactic shock. A trained observer familiar with the operating theatre and the procedures recorded the anaesthetist's interventions (i.e. elements of actions) throughout the entire case applying a new observation method, sensitive to overlapping operations in action sequences. In a previous study the methodological problem of recording and interpreting overlapping operations [2] could be overcome by applying a new computer-based observation method [3]. In order to describe action sequences, we generated quantitative measures of action density that serve as an indicator of the relative amount of overlapping operations. These measures help to analyse the extent to which total activity and particular operations fluctuate during a specific anaesthesia case.

Results: The results of our process-oriented case analysis show that action density exhibits a characteristic and distinct distribution during the conduction of anaesthesia. For example, periods characterized by increased action density are the induction of and the emergence from anaesthesia. These variations in action density during the course of anaesthesia can be observed in clinical as well as in simulator cases. Moreover, in all simulator cases involving unexpected events an increase in action density can be observed during this event.

Discussion: As described in literature on the organization of multiple actions on an individual or group level, concurrent actions may occur due to increased task complexity. By drawing an analogy overlapping operations in action sequences may be interpreted as an indicator for coping with complexity varying during different phases of an anaesthesia case. The comparison of clinical and simulator cases empirically supports the assumption that there are similar action sequences on this level of analysis. Moreover, overlapping operations seem to have a central position when dealing with the various requirements related to the occurrence of unexpected events in a simulator scenario.

Conclusions: The results of this study can be interpreted as an indication of the huge potential of simulators as research instruments when striving for an improved understanding of the anaesthetists' practice in the management of unexpected events. A research strategy integrating clinical and simulator settings has the potential to contribute to the evaluation of simulator settings (e.g. its ecological validity) and thereby lead to improvements in the design of settings for research and training. This will be crucial to assure the quality of education and medical practice in an increasingly complex healthcare system.

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SANTANDER-02-12

Do anaesthesiologists feel alone in the operating room?

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Anaesthetists work in dynamic and complex environments. Teamwork is required and team error can be defined as action or inaction leading to deviation from team or organizational intentions [1]. Effective teamwork is an error-management technique, and communication also has several positive side effects, such as fewer and shorter delays, and increases efficiency [2]. Leadership is an essential ingredient of success in the search for safety, as it is throughout the enterprise of quality [3]. The aim of this study is to assess anaesthesiologists' self-perception regarding their teamwork and team organization. We show preliminary data of a projected broader study.

Methods and Results: 14 staff anaesthesiologists who attended an Anaesthesia Crisis Resource Management course at Santander Simulation Centre were surveyed before and after the course (Tables 1 and 2) to study their self-perception regarding teamwork and team organization.

Table 1. Pre-course survey results.

	Score	
Questions	Yes	No
Do you think you work alone in the OR?	5 (35%)	9 (65%)
Do you think you perform your job as teamwork?	5 (35%)	9 (65%)
Do you warn everybody in the OR when a crisis occurs?	11 (78%)	3 (22%)
I usually call for help when I face an anaesthesia crisis.	14 (100%)	0 (0%)
Have you any sessions with surgeons and nurses?	1 (7%)	13 (97%)
Do you ask surgeons for information of surgery previous to the procedure?	9 (64%)	5 (36%)
Do you usually communicate with surgeons during the procedure?	6 (43%)	8 (57%)
Do you think your job performed as teamwork may improve the outcome?	14 (100%)	0 (0%)

Table 2. Post-course survey results.

	Score	
Questions	Yes	No
Has the course recognised teamwork as a tool of patient safety?	14 (100%)	0 (0%)
Has the course improved your skills of communication?	14 (100%)	0 (0%)
Has the course expanded your leadership skills?	14 (100%)	0 (0%)

Comments
- Speak with surgeons frequently;
- Surgeons are members of the team! (2 comments);
- Leadership is a tool for managing the team;
- Sessions previous to surgery with the team.

Conclusions: The anaesthesiologists surveyed have a poor self-perception about team organization and teamwork during their job. Anaesthesiologists have developed a deficient skill in communication. Simulator training may improve the patient safety by emphasizing the significance of team organization and enhancing communication among the team. From their written and verbal comments, most believed they learned a great deal about teamwork. Because these results are subjective thoughts, it would be necessary to develop an objective measurement instrument, which avoids some of the limitations of traditional approaches to measuring teamwork attributes. It is desirable that simulator training involves complete operating room teams to achieve improved performance [4].

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SANTANDER-02-13

Which scenarios should be included in simulator training? Empirical decision trees predict crises during anaesthesia

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We have developed a model for prediction of crisis during anaesthesia using empirical decision tree methods. Interpretation of such models can help in choosing scenarios for simulation on a statistical base.

Motivation: Anaesthesia is a safe discipline. Experienced anaesthetists know combinations of a patient's state, operation, anaesthesia technique and circumstances, which increase the risk for a crisis during anaesthesia. Training with simulators is aimed to reduce the risks of such crises. For a rational selection of scenarios and standardization of simulator trainings a statistical founding is a prerequisite. Empirical tree methods may help to develop schemes for simulator trainings.

Methods: An empirical tree represents a segmentation of data that is created by applying a series of simple rules. Each rule assigns an observation to a segment based on the value of the target criteria. Such trees enable the user to classify observations and interpret them through the applied logic statements of the segmenting rules. The segmentation can be used as a prediction model of the target criteria. We applied the method to a database of 334 000 incidents of anaesthesia use from 24 hospitals in Germany during 2000. The database structure is based on a proposition for quality management by the German Society for Anaesthesia and Intensive Care Medicine (DGAI) [1] and it codes administrative data, diagnosis, times of anaesthesia and operation, and critical incidents (Anästhesiologische Verlaufsbeobachtung, AVB). We chose the occurrence of relevant AVB as the target criteria for our study, which was carried out using SAS Enterprise Miner V 4.0 [2].

Results: We observed the occurrence of relevant AVB (rAVB) in 1.8% of the cases. The segments found by tree methods showed relative frequencies from 0.4% to 21% for rAVB. The segments can be characterized by the applied segmentation rules. Examples of 2 segments: (a) Patients less than 60 yr old with ASA I or II, non-emergency operation, and duration of the operation less than 3 h, showed an occurrence of rAVB with a relative frequency of only 0.4%. About 15% of the patients fulfilled these criteria. (b) Patients older than 60 yr, ASA III, IV, or V in emergency situation showed a relative frequency of 12% of occurrence of relevant AVB. This applied to 2% of the patients. 75% of the rAVB, which occurred for this group, including 12% with lethal outcome applies to the cardiovascular system.

Conclusions: For choosing the contents and scenarios of simulation classes, empirical decision trees may give a statistical basis. This corresponds to an approach to include knowledge and techniques of quality management into medical simulation. 'Safe anaesthesia', i.e. patients and operations that show a low relative frequency of rAVB, do not need to be trained. Anaesthesia cases that show a high occurrence of rAVB should be included in simulator training. These patients and operations can be detected with the means of empirical trees, and corresponding scenarios can be created and justified. The examined case gives reason for training scenarios in the field of cardiovascular problems for the elderly.

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SANTANDER-02-14

How do anaesthesiologists experience a simulator setting in comparison with clinical settings? Results from an interview study

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Our project investigates the ecological validity of simulator settings by using several sources of data. Besides action sequences we focus on the participants' experience of the simulator setting. This approach acknowledges that actions may be experienced differently, depending on their dynamic context. Both objective and subjective data have to be considered to improve the ecological validity of simulator settings.

Methods: After 18 simulator sessions semi-structured interviews were conducted focussing on setting elements making it feel 'real' or 'simulated/fictional'. Informed consent was obtained from 6 anaesthesiologists (3 first year and 3 third year residents) each taking part in 3 simulator scenarios (1 routine case and 2 containing critical events). The interviews were analysed by extracting 'reality signs' and 'fiction signs' [2].

Results: In the following we focus on reality and fiction signs concerning actions of participants. All participants pointed out that their actions were nearly the same in the simulator setting as in the OR (e.g. cross checking between different sources of information). However, the participants were sometimes uncertain whether to perform certain actions in the simulator setting or not (e.g. using the telephone). Thus emphasizing the formerly stated importance of thorough briefings before simulator sessions [3]. The most prominent fiction sign was the participants' feeling that they were more careful in their clinical decision making (e.g. reading the patient chart several times). Inconsistencies between different sources of information due to not optimally synchronized elements of the simulator setting were particularly difficult in the decision process. The necessity to communicate with other team members or the patient was experienced either as a reality or a fiction sign depending on communication style and content. Some elements – e.g. inability to complete the anaesthesia record during the scenario – were experienced completely different by some participants. While one person thought this to be a fiction sign (the scenario was too short to complete the record) one other person said that he had reacted to the time pressure like in the OR (set priorities: postpone the protocol).

Discussion: Our results highlight the value of dialogue and consensus oriented research striving for ecological validity of simulator settings. The insight gained by interview data is essential for deriving design implications such as the importance to synchronise all elements of the simulator setting very carefully. Nevertheless we need an improved understanding of the processes leading to different experiences of the same elements of simulator settings.

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SANTANDER-02-15

Simulator training for medical emergencies in dental practice

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Prompt recognition and appropriate management of medical emergencies occurring in the dental chair is now regarded as a core competence in the training of general dental practitioners. This study sought to look at the impact of a simulator based course on both theoretical and clinical performance. Preliminary findings from 2 scenarios (scenarios 1 and 4) involving cardiac arrest in the dental chair are reported.

Methods: Ten core medical emergencies were grouped into 5 clinical scenarios, which also formed the basis of a short answer written paper. Seventy-nine final year dental students attended our centre for 2 half-day visits in groups of 8–10. On each visit they were presented with the written examination, then following an introduction and orientation took part in clinical scenarios. Each scenario was followed by debriefing, aided with a video-recording of the scenario, and on the first visit this was in turn followed by some further instruction in the clinical area. On the first visit each group participated in 2 scenarios and on the second visit 4 scenarios. A structured

Table 1. Study results.

		Written test (%)	Clinical performance (%)
Scenario 1	Visit 1	87	34
	Visit 2	85	46 ($P < 0.01$)
Scenario 4	Visit 1	61	42
	Visit 2	67	54 ($P < 0.01$)

marking system based on specimen answers was used to score the written examination and a marking system derived from these was used to mark the technical performance of the students in the clinical scenarios. Related *t*-tests were used to analyse the written scores and independent *t*-tests for the clinical scores. For this study the written scores for the questions relating to scenarios 1 and 4 were analysed rather than the written paper as a whole.

Results: Analysis of the written scores for each of the two scenarios showed no significant difference between the first and second visit scores. In contrast there was a significant improvement in the clinical scores of the second visit (Table 1).

Discussion: The improvement in scores in clinical performance suggests that the brief period of simulator training does have a positive impact on clinical performance, as scores in both groups improved significantly. However, the initial scores on both visits were very low and so it should not surprise that an improvement was seen. The lack of a difference of scores in the written examination does suggest that there is a gap between 'knows how' and 'shows how' to manage a clinical emergency and this raises issues worthy of further exploration.

SANTANDER-02-16

Incorporation of simulation in a newly developed medical curriculum

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The traditional medical curriculum for German medical students is mainly knowledge-based instead of skill-based. So most of the time medical students spend at university they are educated in theory sitting in the lecture theatre. The intermediate and final examinations are also conventionally Multiple Choice Question style. For the last 2 yr the Heidelberg medical faculty took measures to develop a completely different medical curriculum. Based on the experiences of Harvard Medical School, Boston, this new curriculum should be directed much more to skill-based teaching and interactive learning for the students than before. It is labelled 'Heidelberg Curriculum Medicinale' (HeiCuMed). The only department at Heidelberg University presently running a full-scale patient simulator is the Department of Anesthesia. So our department decided to incorporate this simulator into HeiCuMed. During each year of their medical studies our students stay for 2 weeks in the Department of Anesthesia. The schedule for the first week includes: pharmacology of anaesthesia drugs, principles of anaesthesia, intensive care, and pain therapy. In the second week the students are educated in emergency medicine.

The schedule for the first week starts with an interactive seminar with 30 participating students and 2 teachers in the morning. The teachers give lectures using sandwich techniques to offer the students a chance of interacting with each other and the teachers. After a lunch break the students are divided into 3 groups of 10 students each. While 2 of these groups spent 1 h on a case study under faculty supervision there is always 1 group of 10 students at the simulator. Rotation of the students through different departments allows us to teach 150 students within a period of 10 weeks. The 2 case studies are intended for better comprehension and retention of the relevant learning objectives of the morning seminars. During the simulator time the students have to actively solve problems by using the theoretical knowledge they have been taught in the morning. The teacher's role at the simulator is to facilitate this transfer of knowledge into practice.

The concept of this curriculum is the combination of theory, case study, and active treatment of a simulated patient to achieve the given learning objectives. According to current learning theory the best way to achieve these aims is to activate the student during the learning process. By the 1 day schedule of interactive lectures followed by a case study and simulator training we intend to facilitate the students' acquisition of knowledge *and* skills necessary for an improved performance as a physician. The concept of a whole day curriculum allows a limited use of the expensive simulator time as a kind of 'top of the teaching line' instrument. Preliminary results of evaluating students' experience of simulator training show that this kind of training is highly activating and motivating for students.

As the anaesthesia department is by now the only department using a simulator for student education for HeiCuMed other departments, e.g. Internal Medicine, Pharmacology, and Physiology are highly interested in making use of our full scale simulator for their purposes.

SANTANDER-02-17

A study of General Practitioner refresher courses

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The Bristol Medical Simulation Centre (BMSC) has undertaken 7 General Practitioner (GP) half-day refresher courses between January 2001 and February 2002 (Table 1).

Setting the scene: The adult METI Human Patient Simulator was positioned lying face-up fitted with a cannulation arm on a couch reading a book in front of a television to set the scene for a home visit or doctor's surgery. The GPs were briefed with some patient details before each scenario and were equipped with a 'black bag' (Table 2).

Course content: The programme comprised four scenarios interspersed with debriefing.

Scenario 1. After climbing the stairs at home, the patient develops a myocardial infarction leading to cardiac arrest.

Scenario 2. The patient falls in his home and develops an intra-abdominal bleed and simple pneumothorax, which progresses to a tension pneumothorax.

Scenario 3. The doctor is called by the practice nurse to the treatment room to assess a patient who has developed a systemic reaction to a routine inoculation, which results in anaphylactic shock.

Scenario 4. The patient is rushed to the surgery after eating a chocolate covered peanut developing anaphylaxis leading to a 'can't intubate can't ventilate' scenario.

Course feedback: From 50 attendees 32 GPs completed standard BMSC questionnaires. Results were as follows (Table 3).

A selection of comments:

'An enjoyable and extremely useful afternoon. Very realistic scenarios and well acted';
'Excellent, unthreatening atmosphere. Very clear, relevant explanations';
'Much better way of remembering. Staff non-threatening. Thanks';
'Very good. Not as frightening as I thought it would be';
'Useful as both an individual and a group observer';
'Excellent method of teaching, made more aware of what is available to the average GP'.

Table 1. Courses completed (*denotes no feedback for this course).

Date of course	GPs in attendance
11/01/01	5*
25/04/01	7
03/07/01	6
03/09/01	8
05/09/01	9
20/11/01	8
22/02/02	7*
Total	50

Table 2. Contents of 'black bag'.

Content	Quantity
Mini-Trach II® Minitracheotomy Kit	1
A selection of Venflon® cannulae	8
A selection of hypodermic needles	6
A selection of syringes	3
Vecafix i.v. dressings	
A pocket mask	1
Glyceryl trinitrate pumpspray	1
Laryngoscope	1
Guedel airways	2
Endotracheal tubes	2
Glucose Minijet® injection	1
1 mg in 1 mL epinephrine (ampoule)	1
Epinephrine 1:10 000 Minijets®	2
Fursosemide Minijet® injection	1
Isoproterenol Minijet® injection	1
Inhalers	2
1 mL hydrocortisone injection (ampoule)	5
1 mL chlorpheniramine injection (ampoule)	5
Atropine sulphate injection	1
Diamorphine injection	1
Stethoscope	1
Assorted adhesive tape (roll)	2

Table 3. Column 'All' denotes all delegates (GPs, medical students, SHOs, SpRs, dentists, nurses) who have completed questionnaires at the BMSC (excluding national/industry sponsored courses) since opening.

Questions	GPs (%)	All (%)
Q 1. *Do you think the simulator has a role to play in teaching?*	100	100
Q 2. *Has it improved:*		
(a) Your practical skills?	90	77
(b) Your clinical knowledge?	100	93
(c) Your understanding of basic sciences?	63	64
(d) Your confidence in dealing with patients?	94	65
(e) Your familiarity with equipment?	78	77
(f) Your understanding of principles of anaesthesia?	19	66
Q 3. *Would this session have been best covered in:*		
(a) A lecture format?	0	8
(b) A ward round about the bedside?	7	10
(c) A classical tutorial?	4	15
(d) A problem based simulation approach?	94	94
Q 4. *Score in terms on a value of 0–3 spent in:*		
(a) Simulation theatre (GP avg 2.8)	93	90
(b) With cannulation arm (GP average 2.3)	77	73
(c) Lecture room (GP average 2.5)	83	70

Conclusions: General practitioners unanimously think: there is a role for the simulator in teaching and that it greatly improved their practical skills (more so than other groups of delegates); confidence in dealing with patients (in critical situations; more so than other groups of delegate); familiarity with equipment (such as tracheostomy kits) and understanding of basic sciences (using the latest BLS/ALS protocols).

94% of GPs thought that the session was best covered in the simulation centre environment and indicated it as the most useful method of teaching.

Comments: The BMSC has diversified this course by piloting two variations in the GP refresher course for (a) Cardiac GPs and (b) drug specific courses such as a ketamine GP course for BASICS trauma GPs (trauma first responders).

SANTANDER-02-18

Assessment of a full patient simulator for teaching decision-making in emergency medicine

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We have developed a 5 day and 40 h long course on teaching emergency medical techniques for physicians. For the last 4 yr we have organized 4 courses and 320 trainees have passed through the course. The course consists of 20 h of lectures and 10 of practicals, each lasting 2 h. Each course was attended by 8 students. Practicals were: mechanical ventilation, airway management, drugs, ACLS in animal laboratory, management of acute coronary syndromes, dysrhythmias, use of abdominal echography, troubleshooting workshop, managing a poisoned patient, and decision-making in emergency medicine. This last workshop took place in Santander Simulation Centre, using a full-scale patient simulator to create a realistic environment. The aim of this practice was to evaluate and teach dynamic decision making during highly complex clinical scenarios. A short analysis of the case followed each scenario. At the end of the course, all participants completed a questionnaire to assess all aspects of the course (rating scale 1 to 5; 1 minimum and 5 maximum).

Results: Questionnaire results are shown in Table 1.

Conclusions: This course is being well received by participants, as a useful course for their job. This course combines lectures and workshops, which seems to be useful for the trainees. The full patient simulator workshop is the most highly attended practice by students among 11 different workshops. Teaching decision making with a full patient simulator improves the educational value of these courses.

Table 1. Results of the questionnaires.

Topic	Score
Usefulness of the course	4.52
Lectures	3.81
Workshops	4.35
Decision-making with a FPS	4.57
Mechanical ventilation	4.55
Airway management	4.43
Troubleshooting workshop	4.37
Drugs	4.36
Abdominal echography	4.28
Acute coronary syndrome	4.20
ACLS in animal lab	4.19
Dysrhythmias	4.01
Managing a poisoned patient	3.44

SANTANDER-02-19

Patient simulator as test bed for mobile telemedicine applications for medical emergencies – The Guardian-Angel-System

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The implementation of new technical systems in healthcare always bears the risk of inadvertently endangering patients [1,2]. This may be due to the use of the system itself or due to distraction of attention. This effect may even be pronounced while establishing a new safety system in emergency patient care. Until now, the use of telemedical systems to provide help in acute life-threatening situations has been very limited. A realistic simulation environment was used to develop and test the new 'Guardian-Angel-System' (GANS) intended to improve patient safety in medical crisis situations.

Methods: In the 6WINIT (Ipv6-Wireless Internet Initiative) project (www.6winit.org), funded by the European Commission, we developed a real-time, mobile and wireless telemedicine system to provide acute medical help to healthcare professionals outside the hospital in collaboration with the University of Stuttgart Computing Centre and Ericsson Research. The system transmits vital data and video streams via Java and Java Media Framework programs using JDK 1.4 in a Linux environment. All applications are enabled for the future IPv6 (Internet protocol 6) and allow multi-access and seamless handover. The system is designed to improve patient safety by instantly transferring expert knowledge to the emergency scene. As a result of realistic scenarios with the simulator and variable modes of data transmission we qualitatively derived technical specifications from the needs of the experts in the GANS centre and the remote doctors.

Results: To support the physician at the scene it is necessary to transmit all vital data streams, such as blood pressure, oxygen saturation and ECG in real-time to the GANS centre. Otherwise the expert would have to ask repeated questions regarding the vital signs, thus unduly distracting the attention of colleagues. Also, it would be very difficult for the expert to develop a mental model of the patient's condition without continuously monitoring the vital signs. In order to contribute positively to the crisis resource management of a case it proved to be very helpful to have at least one live video stream including audio from the treatment scene. This enables the expert (a) to assess the people involved, (b) to recommend to call for help, (c) to perceive the stress level of the situation, and (d) to decide when to talk to the remote colleague and when to be quiet (e.g. it is disturbing trying to talk to a colleague when he is about to auscultate the chest). The colleague at the scene must be able to start the GANS system by 'one-button-activation' and needs a wireless full-duplex headset for effective communication.

Conclusions: The use of the realistic simulator as a test bed for the new telemedical Guardian-Angel-System led to the specification of several technical requirements, which are otherwise difficult to obtain without endangering patients. In our opinion this innovative use of simulators to develop technical systems for patient safety is a very promising concept for the future [3].

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SANTANDER-02-20

The role of debriefing in simulator training courses for medical students

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Case management and 'hands-on' training is important for the education of medical students in increasing their performance ability in the real world [1]. Simulators provide a means to making critical incidents 'available' for regular training courses [2]. However, to use the full potential of simulator training a real sense of 'hands-on' experience is essential. This is usually achieved in debriefing sessions, which are widely regarded as important [3]. This study was performed to assess the role of debriefing in training courses for medical students.

Methods: Over 2 years, 88 medical students took part in a 1 week simulator training course. The maximum course size was 10 students. Each participant took part in three to four scenarios each followed by an intensive debriefing session. Subsequently students provided feedback by a standardized questionnaire containing 40 closed questions. Each question was answered by marking one out of four answer possibilities (rating scale 1–4).

Results: Participants indicated the experience of the course in whole as intense (94.3% marked 'very intense' or 'intense'). The scenarios itself were rated as stressful (97.7% marked 'very high' or 'high'). Despite this perceived stress, most participants did not suffer from it (58.6% marked 'no suffering'; 24.1% marked 'little suffering'). The debriefings were not rated as intimidating as 81.8% rated 'no' to the question whether the debriefing was 'compromising or attacking'. 94.3% indicated the debriefing to be 'indispensable for a simulator course'. The learning experience during the debriefing was rated as very valuable. 67.5% of the participants marked 'yes' or 'rather yes' to the question whether they learned more during debriefing than during scenarios. Overall, 83.0 % of students indicated that this was the best course during medical school so far.

Conclusions: Students seem to like intense and stressful courses when they provide an unparalleled learning experience. The results indicate two main objectives of debriefing. Firstly, the widely accepted facilitation and transfer of learning from the scenario, and secondly, the modulation and reflection of the experienced stress to prevent it to harm the trainees.

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