SPECIAL REPORT

Interface between Hospital and Fire Authorities — A Concept for Management of Incidents in Hospitals

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Abbreviations:
CoPH = Co-ordinating Physician of the Hospital
CEP = Chief Emergency Physician

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Abstract

Introduction: Although every hospital needs a security plan for the support of immobile patients who do not possess autonomous escape capabilities, little information exists to assist in the development of practical patient evacuation methods.

Hypothesis: 1) In hospitals during disasters, incident leadership of the fire authorities can be supported effectively by hospital executives experienced in the management of mass casualties; and 2) As an alternative for canvas carry sheets, rescue drag sheets can be employed for emergency, elevator-independent, patient evacuation.

Methods: A hospital evacuation exercise was planned and performed to obtain experiences in incident command and to permit calculation of elevator-independent patient transport times. Performance of incident leadership was observed by means of pre-defined checklists. The effectiveness and efficiency of carrying teams with five persons each were compared to those with a rescue drag sheet employed by a single person.

Results: Incident command for hospitals during a disaster is enhanced considerably by pre-defined and trained executives who are placed at the immediate disposal of the fire authorities. For elevator-independent patient transport, the rescue drag sheet was superior to conventional carrying measures because of a reduced number of transport personnel required to move each patient. With this method, patient transport times averaged 54 m/min. flat and 18 seconds for one floor descent.

Conclusion: Experiences from a hospital during an evacuation exercise provided decision criteria for changes in the disaster preparedness plan. Hospital incident leadership was assigned to executives-in-charge in close co-operation with the fire authorities. All beds were equipped with a rescue drag sheet. Both concepts may help to cope with an emergency evacuation of a hospital.

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Introduction

A variety of incidents may threaten the security of a hospital. With regards to the geographical location of an individual hospital, earthquakes, floods, windstorms, and other natural hazards either may be excluded or may only have a minor probability of becoming an event. Remaining in the front row are technological events, such as a fire or prolonged interruption of electrical power.[1,2]

Every hospital must have a plan to support immobile patients who do not possess autonomous escape capabilities. This task is quite complex: success depends on several variables, the most important of which is the relation of patients to auxiliaries during the very first phase of a critical incident.

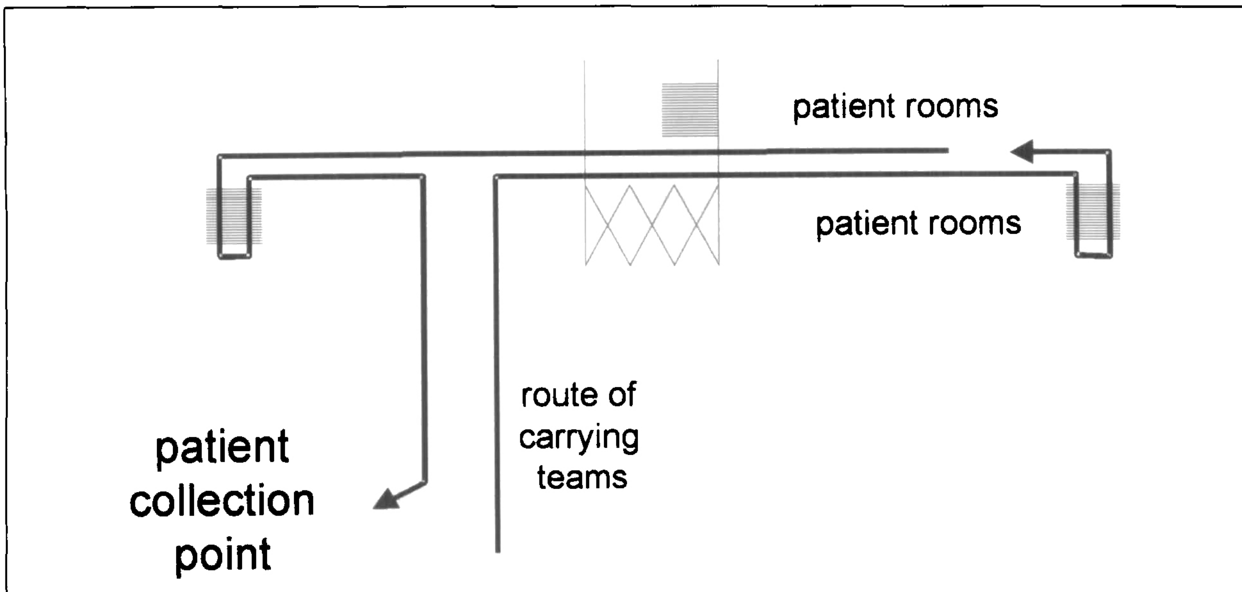

Figure 1—Schematic diagram of the hospital floor

In order to re-evaluate the hospital's disaster preparedness, a patient evacuation exercise was planned and carried out in an 1,100 bed, maximum care hospital. While considering the need to continue with everyday patient care, a realistic dimension of the exercise was chosen. The experiences gained should be transferable to an evacuation of the complete, 11-floors of the building, and design of the exercise had to match this requirement.

The complete breakdown of the hospital's electrical power supply following a fire in the electrical center was assumed to be the reason for the in-patient evacuation. On the day of the exercise, 500 persons in total were employed, including professional and voluntary fire brigades and rescue teams, complimentary medical services, police, municipal transportation services, hospital staff, and patient impersonators. The evacuation exercise was combined with a fire extinguishing exercise in the same building. In addition to patient evacuation out of the building, relocation of patient impersonators to remote quarters was assumed to be necessary.

Since movement of real patients had to be excluded, and impairment of the patients had to avoided as far as possible, the exercise was allocated to a ward in the first upper floor currently vacant following reconstruction. Sectional time measurements of the evacuation performed out of a single ward were scheduled to make a calculation of time and staff requirements for the evacuation of the whole building possible — every story with an identical floor plan.

As core features of any hospital's disaster plan, incident leadership and a patient transport system should be addressed. Mainly, the exercise was conducted to answer two questions: 1) how can patient evacuation be managed effectively in co-operation with the fire brigades and the hospital itself; and 2) what kind of patient transport system is most suitable for an evacuation of the whole building? Corresponding to the second question, an estimation of time and staff requirements was expected to become possible.

Methods

1) Incident leadership

For the day of the exercise, the incident leadership concept of the hospital was modified by defining the new role of a specialised crisis managing physician, called the Co-ordinating Physician of the Hospital (Co-PH). He had completed a basic education course on Incident Tactics in Mass Casualties. His task (together with competent nursing and technical leadership) is intended to provide counsel with the fire authorities' officer-in-charge, and to realise predefined strategies in the hospital. For this purpose, the Co-PH joined the incident command staff who had to cope with the exercise.

The details of the simulated incident had not been notified to the incident commander or to the Co-PH. For communication with the action forces, radio telephony with three separate channels was available. Contact with the hospital personnel was maintained using the internal telephone system.

Evaluation of leadership performance was based on predefined criteria observed by referees, and included appropriateness of communication with the incident commander and his staff, completeness of instruction to the hospital's participants, and effectiveness of measures for co-ordination of transport, and preparation of patient collection points.

The whole sequence was supervised by the Project Preparation Group and referees placed at different locations. For internal communication, this group of persons reverted to an additional radio circuit, which also was used to co-ordinate the different exercise sequences.

2) Patient transport

Because of the limited number of patient rooms at our disposal, it was intended to conduct four sequential evacuations with different patient impersonators and rescue staff each. In every exercise sequence, 12 patient impersonators, eight of

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	Time Flat, without Patient [sec / 100 m]	Time, Flat, Carrying Patient [sec / 100 m]	Upstairs [sec]	Down Stairs [sec]
Group Using Carry Sheet				
Number of procedures	24	24	24	24
Maximum	111	150	17	39
Quartile 0.75	103	113	15	35
Median	**90**	**103**	**15**	**33**
Quartile 0.25	83	90	14	29
Minimum	83	71	14	26
Single Person Using Rescue Drag Sheet				
Number of procedures		8		8
Maximum		133		32
Quartile 0.75		120		23
Median		**111**		**18**
Quartile 0.25		105		18
Minimum		102		16

Table 1—Time consumed (seconds) by patient transport procedures (seconds; m = meters)

them assumed to be unable to walk, had to be evacuated. Communication with the incident command had to be maintained to co-ordinate the evacuation procedures through the stairwells. After every evacuation sequence, placement of new patient impersonators and staff was managed by members of the Project Preparation Group.

In order to assess the time requirements within the staircase, additional patient transport procedures with two patient impersonators each were performed from the stairhead of the 10th upper floor and from the landing of the 8th and 6th upper floors without entering the patient wards. In total, 38 patient impersonators were scheduled to be carried for evacuation. All patient impersonators were transported from the ward to a patient collection point.

Two different patient transport concepts were compared: 1) a conventional canvas carry sheet with grips applied by carrying teams of five persons each; and 2) the Jaerven Rescue Drag Sheet (Jaerven Plast & Smide AB, Oernskoeldsvik, Sweden). This is a mattress pad with attached belt fasteners for patient securing, and with grips at the ends. Using this device, patient transport was executed by a single nurse (or fireman), dragging the patient impersonator on his mattress out of his bed and downstairs. The Jaerven rescue drag sheet was applied for those eight patient impersonators for the last evacuation sequence from the exercise ward.

In order to make time calculations possible for different locations within the building, the times needed within the staircase (up and down), on the patient ward, and on the way to the patient collection point were measured separately. Instruction of the carrying teams ensured that, for every evacuation sequence, the same route was used (Figure 1).

Results are presented as median, interquartile range, and total range. Delineation of exercise design and results were intended to incorporate the Utstein style criteria.[3] There was no financial support from the evacuation sheet's manufacturer with the exception of providing a number of sheets for the day of the exercise. The costs of the exercise were shared between hospital and fire authorities.

Results

1) Incident leadership

The evacuation exercise could be performed safely and without disturbing the routine patient care of the hospital because of the careful pre-information of all parties involved (patients, hospital employees, and neighbouring residents), and by marking-off the access roads by the police.

The most impressive capacity of the Co-PH was that he shared a common language with the incident commander. The Co-PH, because of his knowledge of the internal communication opportunities available, was able to chose a direct way for communication with the affected ward, and to forward complete instructions to the physicians and nurses on the exercise ward without misunderstandings. Communication could be maintained, and demands for carrying personnel were transmitted from the ward to the incident command. As a practical weak point, preparation of the patient collection point did not completely meet the requirements of the actual number of patient impersonators.

Throughout the exercise, the leadership concept of the Co-PH proved to be effective both from the viewpoint of the hospital and the fire authorities. The incident commander appreciated the level of support, working together with hospital executives who were prepared to join his staff immediately. Communication as well as sharing and attribution of different tasks was readily possible. The incident commander could pay attention closely to the fire extinguishing procedure, while the Chief Emergency Physician (CEP) of the public rescue system was able to co-ordinate the activities of the rescue teams outside with those working inside of the hospital, as well as relocation of patient impersonators to remote quarters in the later phase of the exercise. This concept assured that the requirements for in-hospital evacuation procedures were considered by the Co-PH. Communication performance was smooth and provided a true interface between the fire authorities and the hospital administration.

During the debriefing of the exercise, the hospital leadership concept was assigned to the physicians-in-charge for a rapid and daily 24 hour availability. This function now is

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	Floor	Number of Patients Unable to Walk (from Actual Sample) n	Time Calculation for 50 m in Upper Floor [sec]	Staircase Time (Down) [sec]	Time Calculation for 100 m in Basement [sec]	Single Transport Procedure [min]	Total Cumulative Time [min]
Canvas Carry Sheet							
	10	12	52	330	103	7.9	95
	9	16	52	297	103	7.4	118
	8	50	52	264	103	6.9	343
	7	6	52	231	103	6.3	38
	6	16	52	198	103	5.8	93
	5	12	52	165	103	5.3	63
	4	3	52	132	103	4.7	14
	3	5	52	99	103	4.2	21
	2	0	52	66	103	3.7	0
	1	0	52	33	103	3.1	0
	basement	0	52	0	103	2.6	0
Total							**799**
Rescue Drag Sheet							
	10	12	56	180	111	5.8	69
	9	16	56	162	111	5.5	88
	8	50	56	144	111	5.2	259
	7	6	56	126	111	4.9	29
	6	16	56	108	111	4.6	73
	5	12	56	90	111	4.3	51
	4	3	56	72	111	4.0	12
	3	5	56	54	111	3.7	18
	2	0	56	36	111	3.4	0
	1	0	56	18	111	3.1	0
	basement	0	56	0	111	2.8	0
Total							**601**

Table 2—Calculated example of evacuation times for the whole building (based on median data from the exercise and on an actual sampling of patients unable to walk); transport time down only without lead times (min = minutes; sec = seconds)

provided by a group of 12 anaesthesiologists from one of the hospital's anaesthesia standby services who have been educated and experienced in the management of mass casualties. The leadership concept was extended to nursing and technical executives, so that three persons (physician, nurse, technician) represent the hospital's incident management system. This group can be established within minutes of the onset of an incident. Management now is facilitated by checklists based on the degree of threat to each ward and the priorities for necessary preparations. The members of the hospital incident command (anaesthetists, leading nurses, and technicians) meet in a work group regularly with the participation of executives of the fire authorities and the police for further improvement of the preparedness level.

2) Patient transport

Key results of the patient transport section were the times measured along the evacuation route and within the staircase. The median value for the times required for the groups carrying a patient impersonator within the staircase (for one floor) accounted for 15 seconds (up) and 33 seconds (down), respectively. Results of the staircase transports from the 6th, 8th and 10th floor revealed an almost linear correlation of transport speed for all staircase distances. The median flat speed of the carrying groups was calculated as 103 sec/100 m (58 m/min) with patient and 90 sec/100 m (67 m/min) without patient (Table 1).

The comparable data for the Jaerven rescue drag sheet were computed as 18 seconds for one floor downstairs and 111 sec/100 m (54 m/min) flat (median values for all mea-

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	Incident leadership	Patient transport
Identification of questions	Improved performance of hospital evacuation by interfaced leadership ?	Most effective elevator-independent patient transport system?
Design research project	Complex staff exercise; Modified hospital leadership for co-ordination of in-hospital evacuation procedures	Complex staff exercise; Repeated sequential evacuation of patient impersonators from a single ward; Comparison of two patient transport methods *
Data collection	Observation of leadership performance by use of predefined checklists	Sectional time documentation of individual patient transport procedures
Analysis of data	Debriefing in project group and exercise staff	Assessment of statistical distribution of numerical data; Calculation of evacuation times for the whole building
Conclusions	Performance significantly improved by specialised hospital leadership	Drag sheet superior to canvas carry sheet
Recommendations	Focus on staff alerting and pool management	Focus on applicability for different patient groups
Feedback	Reorganisation of hospital disaster leadership	Implementation of rescue drag sheets under every bed mattress

Table 3—Utstein-Style Evaluation of the exercise using the Research Template (* indicators of effectiveness: time and staff requirements for transport procedures)

surements). These times were achieved with one single dragging person. Variables for both methods were the individual weight of the patient impersonator and the physical condition of the transport personnel.

For the carrying groups, the additional time for take-over of the patient impersonator lasted 161 (116–219) seconds (median and range of all passages). Extrapolating the staircase data for the upper floors (which share an identical floor plan compared with the exercise ward), a single patient transport from the 10th upper floor, e.g., by means of this concept would have taken more than 14 minutes employing five carriers.

Lead times for carrying team supply and arrival, patient preparation, and take-over did not occur with the rescue drag sheet method, because the rescue drag sheet already had been inserted into each bed. Thus, a single patient transport from the 10th upper floor by means of the Jaerven rescue drag sheet would only take <6 minutes.

For the whole building, with an actual sample number of 120 patients unable to walk, pure patient transport time from the ward to a patient collection point (assuming a distance of 50 m on the ward and 100 m on the basement level) was calculated by employing the data from the exercise results. In this comparison, lead times were not taken into account to ensure comparability of both transport methods. Cumulative time consumption, disregarding preliminary lead times or possible mismanagement, was 799 min (13 h) for the canvas carry sheet and 601 min (10 h) for the rescue drag sheet (Table 2). The difference results from the rescue drag sheet's advantages with increasing staircase distance, which is accented by the high number of patients in the upper stories.

In an extended calculative simulation, 10 groups (50 carriers), simultaneously carrying patients with the canvas carry sheet without interruption, would reduce cumulative transport time to 80 minutes under ideal conditions. In a real incident, repeated exchange of carrying personnel would become necessary, thus increasing the number of carriers to a multiple of 50.

The same time range could be kept by only eight persons virtually working simultaneously with the rescue drag sheet.

Beyond the advantage in pure transportation time for upper floors, the main aspect is economisation of auxiliaries, and that significant preliminary lead times do not apply for the rescue drag sheet as they do for the carry sheet method.

As a direct result of the exercise experiences, the decision was made to equip all beds of the hospital with the rescue drag sheet, which is now "dormant" under every patient's mattress as part of the hospital's disaster preparedness.

Discussion

Coping with the complex problems, which may arise during a dangerous incident in a hospital, requires structural preparedness. Modern concepts of disaster management include enhancing professionalism of all parties involved with specific attribution of tasks and competence. In the case of mass casualty incidents, securing communication between executives, contributors and auxiliaries is one of the most important objectives. Primary requirements are structuring of decision-making, e.g., by checklists and algorithms, and providing allocation of staff and material.

A need for the evacuation of a whole hospital building is a rare, but not an impossible "mass casualty" situation. With our exercise, we obtained an insight into the complexity and the time dimension for solving this task. The technique and for the time calculations may be transferable to other hospital buildings for use in simulation and planning.

There was clear evidence that preparedness of hospital executives is necessary for effective co-operation with the

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fire authorities. Conventional disaster planning refers to the administrative head of the hospital for leadership in critical incidents,[1] neglecting that immediate availability cannot be secured for 24 hours each day. Alternative emergency plans describe leading functions with specified tasks to be assigned to various persons depending on their presence.[4] In spite of a precise hierarchical description of the tasks and the possibility to train for these procedures, there may remain a lack of understanding of the fire authorities' communication and decision pathways.

For conditions in Germany, the CEP of the public rescue system, who is by law the co-ordinating leader of all medical rescue services in case of a mass casualty, could adopt competence for hospital incidents. However, in most cases this person will not have sufficient insight into the hospital's infrastructure (communication, competence, availability) to supervise tasks within and outside of the hospital with equal effectiveness. The Co-PH of the presented method is intended to work closely together with the CEP. They share the tasks in a way that in-patient evacuation is the responsibility of the Co-PH, while rescue management (in the case of a fire) and the management of patient transport to remote hospitals, should it become necessary, will be the task of the CEP. They are interfaced at the patient collecting point in the hospital, which has to be prepared and managed by the Co-PH. Both are receiving continued training for mass casualty incidents.

Looking at the chronological development of a hospital disaster, a significant disproportion of tasks to implement and auxiliaries available may result during the first phases. Unlike previous recommendations,[2] we would not rely, as a matter of principle, on the operativeness of elevators for arbitrary cases of hospital disasters. The features of a secure elevator technique, as postulated, have not been employed in the recent decade in most hospitals.

An arbitrary number of auxiliaries, e.g. from voluntary rescue organisations, may become available later in the course of the disaster, but not within the initial 30 minutes. Carrying teams, which have been the method of choice for patient evacuation during the last 15 years in Germany, are hard to establish in an adequate numbers, when large scale patient transport via the staircase becomes necessary. In contrast, the rescue drag sheet is able to set an impressive quantity of transport personnel free, which can be distributed by the incident command staff to different locations that are short of auxiliaries. Appropriateness of this evacuation method for different patient groups, e.g., patients after recent major spine or major abdominal surgery, remains to be assessed.

As far as possible, criteria of the Utstein Style Guidelines for evaluation and research in health disaster management[3] have been considered in delineation of our exercise experiences (Table 3). Recommendations to be made for future research include optimising methods for alerting and alerting the pool management in the very early phase of a hospital incident, as well as training standards for hospital executives in preparation of incident management and communication with the fire authorities.

As a further result of exercise preparation, implementation, and evaluation, a continuous education program was deemed to be necessary to support understanding of important measures and increase knowledge of every contributor possibly employed during a critical incident. This education is obligatory for all employees of the hospital and is implemented at quarterly intervals.

Some general aspects must be emphasized, which were not in the scope of our exercise: To alert additional staff, individual telephone communication is not suitable. Automatic messaging systems are forthcoming and should prove to be a secure function. Finally, intensive care units or wards with a comparable level of vital functions support need outstanding attention of the incident command.

Conclusion

The evacuation exercise provided precise information to derive a new incident management concept. Pivotal features of the model are the functioning interface between hospital and fire authorities on the one hand and the elevator-independent patient transport method on the other hand. In our opinion, incident command concept and transport concept cannot be separated from each other. All aspects of hospital preparedness are improved continuously in an ongoing team project in close co-operation with the local fire authorities.

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