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Incidence of complications in intrahospital transport of critically ill patients – experience in an Austrian university hospital

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Inzidenz von Komplikationen beim innerklinischen Transport von kritisch kranken Patienten – Erfahrungen an einer österreichischen Universitätsklinik

Zusammenfassung. *Hintergrund:* Im letzten Jahrzehnt gab es gewaltige Fortschritte beim Transport von kritisch kranken Patienten im Krankenhaus. Obwohl der innerklinische Transport heutzutage als Kontinuum der Intensivbetreuung angesehen wird, stellt dieser immer noch ein spezielles Risiko für die Patienten dar.

Methodik: Diese prospektive Beobachtungsstudie hatte das Ziel, die Häufigkeit von transportassoziierten Komplikationen zu eruieren und zusätzliche Quellen für ein erhöhtes Komplikationsrisiko herauszufiltern. In einem Zeitraum von 8 Monaten wurden alle innerklinischen Transporte von Erwachsenen und Kindern von anästhesiologischen Intensivstationen beobachtet und analysiert.

Resultate: Ingesamt wurden 452 Transporte an 226 Patienten durchgeführt. Die Gesamtrate an kritischen Zwischenfällen war niedrig (4,2%) und es konnte kein direkter Zusammenhang zwischen Mortalität und dem Transportprozess festgestellt werden. Neben bekannten Risikofaktoren wie Beatmung mit positiv endexspiratorischem Druck und Katecholaminbedarf des Patienten, stellte sich der akut indizierte Transport als signifikanter Risikofaktor heraus.

Schlussfolgerung: Verbessertes Management solcher Transporte hat erheblich zur Risikominimierung beigetragen, obwohl nach wie vor besonders im Zusammenhang mit der Schwere der Erkrankung und der Dringlichkeit des Transports ein erhöhtes Restrisiko besteht.

Summary. *Background:* During the past decade, considerable changes and advances have been made in intrahospital transport of critically ill patients. Despite the fact that intrahospital transport is nowadays regarded an extension of the intensive care continuum, it still poses a risk for the patient.

Materials and methods: This prospective, observational study was designed to determine the occurrence rate of transport-related complications in the altered setting of intrahospital transports and to identify possible confounding sources of increased risk. In an eight-month period, adults and infants from anesthesiologic intensive care units were analyzed.

Results: A total of 226 patients underwent 452 intrahospital transports. The overall rate of critical incidents was low (4.2%) and no direct association between mortality and intrahospital transport was observed. In addition to the known risk factors of ventilatory support with positive end-expiratory pressure and requirement for catecholamine support, the necessity for intrahospital transport in the acute vs. elective situation was found to significantly increase the risk of complications.

Conclusions: We conclude that advances in the management of intrahospital transport of critically ill patients have led to an overall decrease of complications. However, an undeniable risk remains, especially in relation to disease severity and the urgency of such transports.

Key words: Intrahospital transport, complications, risk factors.

Introduction

The care of critically ill patients often requires investigations and procedures that cannot be performed at the bedside. Despite the increased availability of mobile diagnostics [1] and bedside therapeutic interventions [2], intrahospital transport of intensive care unit (ICU) patients often remains necessary for optimal therapy. The decision to transport an ICU patient is weighed on the expected benefits of the diagnostic or interventional procedures versus the risks caused by the transport [3–6].

The minimal standards recommended by the Society of Critical Care Medicine [7], including concepts such as pre-transport stabilization of the patient, careful preparation of the equipment and proper education of the accompanying personnel, have become essential for the organization and performance of such transports. But the incidence of complications still remains a problem [8] and there is considerable danger for patients to leave the ICU environment, especially for certain subgroups such as postoperative patients and those with severely impaired pulmonary function or head injuries [9–13].

To examine the frequency of transport-related complications and their relationship to the underlying disease and transport-specific issues in an Austrian university hospital, we conducted an eight-month prospective observational study of all patient transports in three ICUs at our institution. We also documented our management of intrahospital ICU patient transports in order to compare it with transport concepts published by similar institutions.

Materials and methods

The institutional review board waived the necessity of obtaining patients' informed consent for this prospective observational study.

All intrahospital transports for diagnostic and therapeutic purposes in patients admitted to three different anesthesiologic ICUs (a total of 22 beds) at the University Hospital of Vienna were studied prospectively during an eight-month period. Transports prior to definite admission to one of these ICUs were excluded. An APACHE II score, assessed in the first 24 hours after admission, was used to classify each patient's illness. The sample of patients does not include critically ill patients admitted to a specific coronary care, neurosurgical or medical ICU.

Forty different anesthesiologists (mostly staff anesthesiologists or residents) were responsible for all the observed intrahospital transports; of these, 15 anesthesiologists accompanied more than five transports each.

The total time including the establishment of regular monitoring and ventilation was regarded as the transport time.

After the ICU physician team cleared each of the study patients for intrahospital transport, the following standard transport regimen was applied. Normally only one anesthesiologist (usually one of the ward on-call residents or staff anesthesiologist) escorted the transport. Our nurses' policy is to prepare the patients, together with the equipment and necessary medication, but not routinely to accompany the patients during the transport. Exceptions were made for pediatric patients and when deemed necessary by the attending anesthesiologist, depending on the transport type, medication used and equipment magnitude. Couriers were not trained in physician support.

All patients were transported in their own ICU bed, in order to decrease the risk of equipment-related complications (e.g. loss of intravenous access), and to minimize hemodynamic instability associated with bed-to-bed transfers. All essential medications were continued with battery-operated perfusor pumps, and sedation was continued at the pre-transport level. Muscle relaxants for mechanical ventilation tolerance were administered when necessary. Emergency drugs were taken along as described [7]. Defibrillators were not taken along, because of their high level of availability at our institution.

If patients were previously on mechanical ventilation, this was maintained during transport by means of two different time-cycled, constant-volume, gas-powered portable ventilators (Oxylog and Oxylog 2000, Draegerwerk AG, Luebeck, FRG). Respiratory rate and tidal volume during transport were set to the same adjustments as were used in the ICU, with the exception of the inspired oxygen fraction (FiO2), where only "air mix" (FiO2 0.45%) and "no air mix" positions (FiO2 = 100%) could be chosen. Positive end-expiratory pressure (PEEP) was maintained using a valve at the exhalation port. In patients suffering severe acute respiratory distress syndrome (ARDS) with the need for variable inspiratory-expiratory ratios or other sophisticated pressure, flow or volume delivery characteristics, ICU ventilators in combination with a power supply were used (Siemens Servo 900, Siemens, FRG). If nitric oxide therapy was required because of the underlying diagnosis and had to be continued during transport, a portable power-supplied delivery system (Pulmonox-mini™, Messer Griesheim, Austria) was taken along.

Manual ventilation was performed when no appropriate transport ventilator was available (all pediatric patients) or if mechanical ventilation had to be established during transport and no transport ventilator had been prepared. Extracorporeal resuscitation devices, such as veno-venous extracorporeal membrane oxygenation (ECMO) and intraaortic counter pulsation, were continued during the transport while using an ICU ventilator as described.

Monitoring included a portable device for measurement of pressure (arterial, central venous, pulmonary arterial and intracranial when necessary), pulse oximetry, respiratory rate and end expiratory CO_2 (Hewlett Packard, CMS transport monitor M1275 A, USA). A standard package of airway management equipment, a resuscitation bag adapted to the patient, and a suction device were also carried along.

Transport-related complications were divided into adverse events, defined as physiologic deterioration or equipment related-mishaps [14], and critical incidents, defined as adverse events potentially detrimental to the patient's outcome [15].

All complications were noted, regardless of whether an intervention was necessary or not. Physiologic deterioration during transport was defined as significant changes in physiologic variables (heart rate, respiratory rate, blood pressure, intracranial pressure); that is, either a $\geq 20\%$ change from pretransport values or a change beyond the normal ranges lasting for ≥ 5 minutes. A significant change in oxygen saturation was defined as $\geq 5\%$ reduction in oxygen saturation lasting ≥ 5 minutes. Equipment-related mishaps included dislodgement of an endotracheal or tracheostomy tube, obstruction by excessive pulmonary secretions, and accidental extubation or removal of any catheter, tube or probe, such as intravenous, arterial, central venous or pulmonary artery catheters. The loss of an indwelling urinary catheter, nasogastric or chest tube or an intracranial pressure probe, the unanticipated loss of oxygen or power supply or any malfunction of equipment [14], including any accidental damages, were also noted.

Statistical analysis

The SPSS™ statistical program was used for analyses. Differences in mean values between groups were compared using

Table 1. Number of adults and children admitted to the ICU and transported and primary patient diagnosis

Adults/children	Admitted 545/80 patients (percentage)	Transported 197/29 patients (percentage)
Primary diagnosis		
Trauma	113 (18%)	95 (42%)
Surgery	256 (41%)	34 (15%)
Thoracic surgery	138 (22%)	14 (6%)
Transplant	19 (3%)	11 (5%)
Post-resuscitation	13 (2%)	5 (2%)
Miscellaneous	88 (14%)	68 (30%)

Table 2. Patient characteristics and life-support modalities

Age	Children	2.9 years (1–13)	[median and range]
	Adults	49 years (16–86)	[median and range]
Sex	Male/Female	151/75	
APACHE II Score	18.5 ± 8.5		

Life support modalities	Percentage	Absolute values of all transports
Vasoactive drug therapy	62%	280
Single catecholamine	30.1%	136
Two catecholamines	26.8%	121
≥ Three catecholamines	5.8%	26
Ventilatory support	79%	357
Intracranial pressure monitoring	11.5%	52
Extracorporeal membrane oxygenation	1.5%	7
Intraaortic counter pulsation	1%	5

a *t*-test for normally distributed data, and Wilcoxon rank sum and Kruskal-Wallis tests for non-normally distributed data.

Spearman's nonparametric rank correlation was used for analysis of the relationship between the APACHE II scores, duration, acuteness, repetition of transport, number of accompanying persons, mechanical ventilation and catecholamine support. The outcome variables were: *i*) any critical incident, *ii*) any physiologic deterioration, and *iii*) any equipment-related mishap.

A P value of <0.05 was considered statistically significant. Unless otherwise indicated, results are expressed as mean ± standard deviation.

Results

A total of 625 patients were admitted to the three ICUs during the eight-month observation period. Of these, 226 patients underwent a total of 452 intrahospital transports. The primary diagnoses of the patients are given in Table 1.

No individual increase in adverse events was observed among the 15 anesthesiologists who accompanied more than five transports ($P=0.23$). No adverse events were registered during the preparation for the transport (i.e. establishment of regular monitoring) on the ICU.

About 20% of the transports were accompanied by more than one person, but the number of escorts had no influence on the occurrence rate of complications. However, a positive correlation of escorts present and disease severity, as assessed by APACHE II scores, was observed ($P<0.01$).

Patient and transport characteristics are summarized in Tables 2 and 3, respectively. Ventilation characteristics are given in Table 4.

Deterioration of physiologic variables occurred in nearly 30% of adult transports and 60% of pediatric transports. A significantly higher risk for physiologic deterioration and critical incidents was identified in patients with continuous catecholamine support and in artificially ventilated patients, particularly those with PEEP exceeding 5 cmH_2O ($P<0.05$). APACHE II scores correlated with

Table 3. Transport characteristics in 452 intrahospital transports

		Absolute values of all transports	(Percentage)
Transport type	Diagnostic	316	(70%)
	Intervention	66	(14.6%)
	Revision	70	(15.5%)
Destination	Computed tomography scan	253	(56%)
	Magnetic resonance imaging	9	(2%)
	Miscellaneous (radiology)	54	(12%)
	Operating room	118	(26%)
Escorts	Single anesthesiologists	366	(81%)
	≥ 2 escorts	86	(19.0%)
Duration	45 ± 37 min (mean ± SD)		
During daytimes	62% On-call	172	(38%)
Acute	22% Elective	353	(78%)
Complications	Physiologic deterioration	118	(26%)
	Equipment-related mishaps	47	(10.4%)
	Critical incidents	19	(4.2%)

Table 4. Ventilation characteristics in 452 intrahospital transports

	Absolute values (percentage)
Spontaneous breathing	95 (21%)
Manually ventilated	41 (9%)
Mechanically ventilated	316 (70%)
Portable ICU respirators	36 (8%)
Nitric oxide therapy	18 (4%)
Oxylog and Oxylog 2000	262 (58%)
Total number of transports using PEEP	324 (72%)
PEEP $\geq 5\,cm\,H_2O$	145 (32%)
PEEP $\geq 10\,cm\,H_2O$	17 (4%)

physiologic deterioration but not with occurrence of critical incidents.

The total rate of critical incidents was 4.2% (19 of 452 cases, Table 5). No transport-related adverse outcome or mortality was observed. Emergency transports, defined as transport required because of immediate need for diagnostic or therapeutic intervention, carried a considerably higher risk of critical incidents than planned transports (7.8% vs. 2.4%, respectively, $P<0.05$). Sixteen of the 19 cases of critical incidents were a consequence of physiologic derangements, whereas only three resulted from equipment-related mishaps.

The complication rate was not influenced by the fact that roughly half of the adult patients underwent multiple (>2) transports. The trend towards multiple transports was not observed in children.

Trauma patients and medical admissions (i.e. pancreatitis, multiple organ failure) had a higher incidence of transport for diagnostic and therapeutic interventions, whereas surgical patients were transported mostly for revisions, defined as planned interventions.

No relationship could be detected between outcome variables and the transport type, destination, duration or whether the transport was performed during a night- or day-shift.

Transported children (29 patients), ARDS patients (18 patients) and patients on ECMO support (5 patients), aortic counter-pulsation (4 patients) or nitric oxide therapy (14 patients) constituted only a minority of our large collective; this resulted in an unintended lack of statistical power in these subgroups.

Table 5. Critical incidents in 19 of 452 intrahospital transports

Equipment related complications (n = 3)	
Unintended extubation	1
Near-extubation + loss of chest tube	1
Portable respirator defect	1
Physiological derangements resulting in critical incidents (n = 16)	
Persistent brain pressure crisis	2
Bronchospasm	1
Severe hypotension	
Caused by bradyarrhythmia	4*
Caused by tachyarrhythmia	6*
Miscellaneous causes	3
Hypertensive crisis	1
Asystole	2*
Resuscitations	5*
Mechanical resuscitation	1
Drug resuscitation	5

*As part of combined complications.

Discussion

We analyzed 452 intrahospital transports of 226 ICU patients. The rate of critical incidents was 4.2% (Tables 3 and 5). Historic rates of critical incidents ranged between 8.1% [16] and 21.4% [15] but comparison with recent rates is difficult as critical incidents are often included in broader categories of complications [8].

The concept of a careful equipment check and patient stabilization before transport has led to a lower incidence of physiologic deteriorations, as reported by Runcie et al. in the setting of interhospital transports [17]. However, long-lasting stabilization before transport might not be feasible in emergency situations, and in such cases it is deemed to be an ongoing activity during transport. This could explain the significant increase of critical incidents in emergency transports in our sample. Interestingly, Smith et al. found the opposite in a smaller investigation of 125 transports [5] and Lovell et al. did not observe any difference in the incidence of complications between emergency and elective transfers [8].

Equipment-related mishaps did not differ between our samples of emergency and planned transports, thus reflecting adequate preparation.

Decisions to transport children might have unintentionally been influenced by the reported higher risk [14], which in turn justified the two-person accompaniment. In fact, the complication rate differed only slightly between adults and children in our study and only in the incidence of hemodynamic disturbances; this was twice as high in children as in adults and could be attributed to the higher number of manual ventilations [3]. However, the transport policy did not allow specific comparison of child samples vs. adult samples and therefore the detection of clinically relevant differences was not feasible.

Although the small collective of patients transported under ECMO support, aortic counter pulsation or inhalative nitric oxide therapy lacks sufficient statistical power, it highlights the need to employ staff experienced in all aspects of intensive care to transport critically ill patients.

As described by Connolly et al. and Szem et al. [15, 18] the incidence of adverse events (e.g. loss of drains, accidental extubation, significant changes in physiologic variables, etc.) and unexpected problems could be reduced by using only trained personnel or a dedicated transport team. Concepts that include ongoing education of the personnel involved in transports were therefore developed. A team approach between nurses, physicians and respiratory therapists is also recommended [7, 19].

Respiratory therapists are not common in Europe and, because of staffing constraints (e.g. individual nurses responsible for more than one patient), nurses are involved only in the pre-transport preparation of the patient but do not routinely leave the ward [15], except in cases deemed necessary by the attending anesthesiologist. Though a weak correlation between the severity of illness and the number of accompanying personnel (i.e. an additional physician or nurse in about 20% of transports) could be detected, no relationship between the frequency of adverse events and the number of escorts was found.

The frequency of complications did not differ within the subgroup of fifteen anesthesiologists who performed more than five transports. This may result either from their level of education or reflect the fact that physicians involved in transports are educated by the ward seniors.

Although several studies underline the instability of physiological variables and oxygenation indices in manual ventilation [11, 12, 20–22], there remains a percentage of transports that cannot be handled by transport ventilators, for various reasons such as emergency transport or equipment shortages. However, this emphasizes the importance of tidal volume control and endexpiratory CO_2-monitoring.

In our sample, transport ventilators were used in most of the patients, with exception of ARDS and ECMO patients where a portable ICU ventilator was used. Statistical differences in complication rates and alteration of physiologic variables could not be detected in this special subgroup, probably because a stable hemodynamic situation was maintained with adequate mechanical ventilation.

In conclusion, despite improved management, the risk of critical incidents during intrahospital transport of ICU patients remains. Disease severity is correlated with higher risk of physiologic deterioration. Emergency transports, continuous catecholamine support and mechanical ventilation with PEEP >5 mmHg are also independent risk factors for a higher rate of critical incidences. With the use of appropriate equipment and well trained personnel the expected benefits exceed the risks of transportation, as demonstrated by the low rate of critical incidents in our collective.

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