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Short-term outcomes and mortality after interhospital intensive care transportation: an observational prospective cohort study of 368 consecutive transports with a mobile intensive care unit

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ABSTRACT

Objectives: To evaluate short-term outcomes and mortality after interhospital transportation of intensive care patients performed by a mobile intensive care unit (MICU).

Setting: This study was performed in the tertiary care process of interhospital transportation using the local MICU system in the South East of the Netherlands.

Participants: Between March 2009 and December 2011, all transports of adult patients being performed by the local MICU centre have been documented; data on 42 variables, including a 24 h follow-up Sequential Organ Failure Assessment (SOFA) score of 368 consecutive interhospital transports of intensive care patients, were recorded. In 24 cases, the follow-up SOFA score was missing, so 344 data sets were included.

Interventions: No interventions have been done.

Primary/secondary outcome measures: Primary outcome measures were the mean SOFA score before and 24 h after transport, and the 24 h post-transport mortality. Moreover, the differences between the groups of 24 h post-transport survivors and non-survivors have been analysed.

Results: The mean SOFA score before transport was 8.8 for the whole population and 8.6 for those patients who were alive 24 h after transport, with a mean SOFA score of 8.4 after transport. The adverse events rate was 6.4%. Fourteen patients (4.1%) died within 24 h after transport. Patients in this group had a higher SOFA score, lower pH, higher age and more additional medical support devices than those patients in the survivor group.

Conclusions: The non-significant decrease in the post-transport SOFA score and the lack of an association between transport and 24 h post-transport mortality indicates that in the study setting, interhospital transportation of intensive care patients performed by a MICU system was not associated with a clinically relevant deterioration of the patient.

INTRODUCTION

Transport of critically ill patients is known to be a high-risk procedure with a significant

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Strengths and limitations of this study

- With our study, we generated relevant and new outcome data on critically ill patients who underwent interhospital transportation by comparing the Sequential Organ Failure Assessment (SOFA) score on the day of transport with the 24 h post-transport SOFA score.
- We briefly analyse all cases of 24 h post-transport mortality.
- This study is a descriptive analysis of a single-centre database with a limited number of patients and with only one post-transport data set (SOFA score) 24 h after mobile intensive care unit transport.
- Owing to the single-centre characteristic of the study, selection bias cannot be ruled out.

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rate of adverse events; nearly 68% of serious adverse events have been documented in up to 89% of intrahospital transports.[1] The adequate provision of qualified and experienced staff along with specially designed and well-maintained equipment are found to be protective,[2–5] especially since during the interhospital transportation, the patients' safety can be compromised due to the absence of qualified medical staff and the lack of adequate resuscitation equipment.[6–10] In a report of the Dutch healthcare authority 'Inspectie voor de Gezondheidszorg' from 2005, the authors concluded that interhospital transports in the Netherlands were often performed with inadequately staffed and underutilised transport facilities.[11] Therefore, the Dutch government by law assigned seven tertiary hospitals to carry out interhospital transports of critically ill adult patients by a mobile intensive care unit (MICU) daily, from 07:00 until 23:00. Patients in need of an immediate life-saving intervention in an expertise centre were beyond the scope of MICU transportation.[12]

A MICU generally consists of a high-volume ambulance, a special trolley with all monitoring, resuscitation and treatment equipment fixed to it and a dedicated retrieval team, including an ambulance driver (from the local emergency medical service), an intensive care nurse and an intensive care physician (both from the local tertiary intensive care unit (ICU)). All clinical team members are trained in the local simulation centre before performing the first transport and the first couple of transports are under direct supervision of an experienced colleague.

Debriefing takes place routinely; all critical events that occurred during transport have been discussed with the medical coordinator and have been registered nationally. Furthermore, there is a 1-day simulator-based follow-up training for all clinical MICU team members once a year.

The Sequential Organ Failure Assessment (SOFA) score is an established, good validated intensive care score which is used to describe worsening or improvement in the patient's condition and has a good correlation with mortality, with a higher score indicating worse outcome.[13] For all transports, the SOFA scores have been calculated at the day of transport and 24 h after transport. In this paper, changes in these two SOFA scores are used to describe short-term outcome. Moreover, regarding the patients who died within the first 24 h after transport, we performed further analysis to determine if there were transport-related effects on the 24 h post-transport mortality.

OBJECTIVES

To evaluate short-term (24 h after transport) outcome and mortality after interhospital transports of intensive care patients in the South East of the Netherlands.

MATERIALS AND METHODS

All transports performed by the MICU Maastricht between March 2009 and December 2011 were prospectively documented. All relevant data were obtained from the patient charts and transferred into a dedicated database by a data manager of the ICU department. All interhospital transports concerned adult intensive care patients in the southeast region of the Netherlands. Forty-two items were scored, including patient demographics; diagnosis; SOFA score pretransportation and post-transportation; use of vasoactive medications; ventilator settings; transport-related factors such as transport time, transport team members; additional medical devices such as extracorporeal membrane oxygenation (ECMO) or intra-aortic balloon counter pulsation (IABP); and critical events. Critical events were registered following national definitions with technical (eg, ambulance, trolley, equipment-related) and non-technical events (eg, drop in oxygen saturation by more than 10% or drop in mean arterial pressure by more than 20 mm Hg for at least 10 min). The MICU nurse called the receiving ICU 24 h after the transport to obtain information about the patient's status (deceased or if alive actual SOFA score).Only transports with complete data sets, including a pretransport and a post-transport SOFA score, were analysed. All transports were performed and documented by a specialised retrieval team. In 24 from the 368 cases, the follow-up SOFA score was missing; so 344 data sets were included for analysis.

Numerical variables are presented by mean (SD) or median (range) if the data are clearly not normally distributed based on histograms. For categorical variables, frequency (%) is given. Differences in numerical variables between patients who died versus patients who did not die within 24 h after transport were analysed using independent samples t tests or Mann-Whitney U tests, wherever appropriate. χ^2 or Fisher's exact test was used for categorical variables. All analyses were performed using the Statistical Package for the Social Sciences (V.20.0, SPSS Inc, Chicago, Illinois, USA).

A two-sided p value ≤0.05 was considered statistically significant.

RESULTS

Patient characteristics

A total of 368 transports were performed from March 2009 until December 2011, from which 344 data sets were complete. A broad range of patients, in terms of severity of illness (mean SOFA score 8.8, range 0–20), were transported, including 15 patients on ECMO. Nearly all patients were mechanically ventilated and the majority of the patients were in need of a higher level ICU or for advanced treatment options, for example, heart transplantation or treatment in a burn unit. The median days of admission before transport was 4, reflecting the fact that urgent transports were not performed with the MICU system. Additional medical devices as ECMO, nitric oxide (NO) or IABP, indicating severe illness, were present in 6.4% of the transports.

In the subgroup of patients transported with veno-venous ECMO, all devices have been placed off centre by the transport team supported by a perfusionist from the local tertiary centre. The data of this subgroup are separately described in the tables 1 and 2.

Transport characteristics and outcome parameters

There is a non-significant decrease in SOFA score after transport (8.6 vs 8.4, p=0.174) for the group to be alive 24 h after transport (n=330). In total, there were 22 critical events reported with 2 severe events needing immediate interventions (spontaneous ventricular tachycardia, disconnection of hub from ECMO tubing system). The majority of events were technical problems, for example, with the power supply of the ambulance or one of the medical devices. None of the latter problems affected the patient's safety because the transport trolley has a stand-alone time from 2 h and back-up devices for ventilation, monitoring and resuscitation can be found in the ambulance.

Table 1 Patient characteristics

Number (%)	344 (100)
Age (SD)	58 (16.4)
Male sex (%)	236 (68.6)
SOFA score before transport (SD/range)	8.8 (4.1/0–20)
Need for higher level ICU or advanced therapy (%)	218 (63.4)
Median days of hospital admission before transport (range)	4 (0–244)
P/F ratio (SD)	246 (113)
Use of continuous vasoactive medication (%)	152 (44.2)
pH at time of request for transport (SD)	7.37 (0.1)
Additional medical devices (%)	22 (6.4)
Invasive mechanical ventilation (%)	311 (90.4)
Non-invasive mechanical ventilation (%)	6 (1.7)

	V-V ECMO	V-A ECMO	All ECMO patients
Number	7	8	15
Age (SD)	40 (15.9)	52 (8.6)	46 (13.4)
Male sex (%)	5 (71.4)	7 (87.5)	12 (80.0)
SOFA score before transport (SD/range)	14.0 (1.5/13–17)	13.8 (2.4/11–17)	13.9 (2.0/11–17)
Days of hospital admission before transport (median/range)	3 (0–27)	4 (2–10)	4 (0–27)
P/F ratio (SD)	92 (41)	240 (87)	177 (106)
Use of continuous vasoactive medication (%)	6 (85.7)	6 (75.0)	12 (80.0)
pH at time of request for transport (median/SD)	7.28 (0.1)	7.45 (0.1)	7.37 (0.12)

Vasoactive medication: norepinephrine, dobutamine, nitroglycerine.
Additional medical devices: V-V and V-A ECMO, IABP, NO.
Short-term cardiac assist devices: V-A ECMO or IABP.
ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon counter pulsation; NO, nitric oxide; P/F, PaO₂/FiO₂ ratio; SOFA, Sequential Organ Failure Assessment; V-A ECMO, veno-arterial ECMO; V-V ECMO, veno-venous ECMO.

The mean total transport time was 5.6 h, which can be explained by the decentred position of the Maastricht Medical Centre and the absence of heart/lung transplantation and burn units in our region. Furthermore, we found that the 15 ECMO transports exceeded the mean transport time by nearly 4 h (table 2).

Mortality

In all, 14 patients died within 24 h after transport (4.1%). We compared the group of patients who died with the group of patients who were alive 24 h after transport. Those patients who died within 24 h after transportation had a significantly higher SOFA score before transport

Table 2 Transport characteristics and outcomes

SOFA score before transport of all patients (SD/range)	8.8 (4.1/0–20)
SOFA score before transport of patients being alive 24 h after transport (SD/range)	8.6 (4.0/0–19)
SOFA score after transport (SD/range)	8.4 (4.5/0–24)
Patients deceased within 24 h after transport (%)	14 (4.1)
Patients not being transported (%)	2 (0.6)
Critical events (%)	22 (6.4)
Total transport time in hours (SD/range)	5.6 (1.9/1.5–11.5)

	V-V ECMO	V-A ECMO	All ECMO patients
SOFA score before transport (SD/range)	14.0 (1.5/13–17)	13.8 (2.4/11–17)	13.9 (2.0/11–17)
SOFA score after transport (SD/range)	15.0 (4.2/12–24)	12.2 (2.1/10–16)	13.7 (3.6/10–24)
Critical events (%)	0 (0)	2 (25.0)	2 (13.3)
Transport time in hours (SD/range)	9.9 (1.4/8.5–10.75)	8.7 (2.7/5.5–11.5)	9.3 (2.2/5.5–11.5)
Patients deceased within 24 h after transport (%)	0 (0)	2 (25.0)	2 (13.3)

Total transport time: departure MICU team from our unit until return of the team plus time for updating the trolley.
Vasoactive medication: norepinephrine, dobutamine, nitroglycerine.
Additional medical devices: V-V and V-A ECMO, IABP, NO.
Short-term cardiac assist devices: V-A ECMO or IABP.
ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon counter pulsation; MICU, mobile intensive care unit; NO, nitric oxide; SOFA, Sequential Organ Failure Assessment; V-A ECMO, veno-arterial ECMO; V-V ECMO, veno-venous ECMO.

(12.3 vs 8.6, p<0.001) indicating a higher severity of illness, were older, more often on vasoactive medication and more frequently had a cardiac diagnosis.

No differences were found in transport-related factors in terms of the number of critical events or total transport time (table 3).

To get more insight on the individual cases of those patients who died, we reviewed the patients' charts. Two patients died after arrival of the transport team in the referral hospital before transportation could be initiated because of massive bleeding and after massive aspiration.

Two patients with postcardiotomy left ventricular failure, transported with veno-arterial ECMO (V-A ECMO) and IABP, died in the perioperative period of surgical implantation of a left ventricular assist device. More than one-third of the patients (5/14) died within 24 h because the medical team decided to retain further therapy; three patients died due to refractory cardiogenic shock and two patients went into a pulseless electric activity secondary to multiorgan failure (table 4).

DISCUSSION

This study shows that interhospital transportation of critically ill patients with our MICU and a dedicated team can be performed without clinically relevant negative effects on the patient's condition and a critical event rate in line with current literature. The monitoring of severity of illness on the day of transport and 24 h after

transport was introduced as a new parameter that can be used to detect transport-related effects on the patients' condition. The patients who died within 24 h after transportation had a higher severity of illness, were older, more often on vasoactive medication and most had a cardiac diagnosis.

Within the ongoing discussion concerning concentration of healthcare facilities, it is to be expected that qualified transport of critically ill patients will become a key factor of success in future intensive care medicine development.[14–17] In this context, it seems to be of utmost importance not only to have qualified interhospital transportation systems, but also to develop practical and efficient tools that help to decide which individual patient will benefit from transportation to another hospital without undergoing major transportation risk. In 5 of the 14 patients who died within 24 h after transport in our population, further aggressive treatment was withheld in the accepting ICU. Retrospectively, it is questionable whether all these patients should have been transported, which emphasises the need for valid pretransport triage criteria.

In 2012, Barratt et al[18] concluded, in a propensity-matched cohort analysis with more than 300 000 patients, that there was no statistical significant difference in hospital mortality for the 759 patients undergoing a non-clinical interhospital critical care transfer, but that a level of harm, that may be considered as clinically relevant, cannot be ruled out.

Table 3 Characteristics of patients alive and deceased within 24 h after transport

	Patients alive 24 h after transport (n=330)	Patients deceased within 24 h after transport (n=14)	p Value
Age (SD)	58 (16.6)	68 (7.5)	<0.001
Male sex (%)	227 (68.5)	9 (64.3)	0.722
SOFA score before transport (SD/range)	8.6 (4/0–19)	12.3 (3.5/9–20)	<0.001
Need for higher level ICU or advanced therapy (%)	206 (62.4)	12 (85.7)	0.076
Critical events (%)	21 (6.4)	1 (7.1)	0.611
Total transport time in hours (SD/range)	5.6 (1.9/1.5–11.5)	5.5 (1.7/4–8.5)	0.850
Median days of hospital admission before transport (range)	4 (0–244)	4 (0–19)	0.072*
P/F ratio (SD)	249 (113)	192 (96)	0.064
Use of continuous vasoactive medication (%)	142 (43.0)	10 (71.3)	0.036
pH at time of request for transport (SD)	7.38 (0.09)	7.23 (0.18)	0.011
Cardiac diagnosis (%)	75 (22.7)	9 (64.3)	0.001
Additional medical devices (%)	19 (5.8)	3 (21.4)	0.052
Short-term cardiac assist devices (%)	11 (3.3)	3 (21.4)	0.015
Invasive mechanical ventilation (%)	298 (90.3)	13 (92.9)	>0.999
Non-invasive ventilation (%)	5 (1.5)	1 (7.1)	0.222
Oxygen supply nasal or mask (%)	27 (8.2)	0 (0)	0.613

*Mann-Whitney U test.
Total transport time: departure MICU team from our unit until return of the team plus time for updating the trolley.
Vasoactive medication: norepinephrine, dobutamine, nitroglycerine.
Cardiac diagnosis: CPR, severe valve dysfunction, cardiogenic shock, myocardial infarction.
Additional medical devices: V-V and V-A ECMO, IABP, NO.
Short-term cardiac assist devices: V-A ECMO or IABP.
CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon counter pulsation; ICU, intensive care unit; MICU, mobile intensive care unit; NO, nitric oxide; P/F, PaO$_2$/FiO$_2$ ratio; SOFA, Sequential Organ Failure Assessment; V-A ECMO, veno-arterial ECMO; V-V ECMO, veno-venous ECMO.

Table 4 Patient characteristics and cause of death of patients deceased within 24 h after transport

n	Major diagnosis before transport	SOFA score	Reason for transfer	Special remarks	Cause of death
1	Cardiogenic shock, severe aortic valve stenosis	13	Further treatment in EC		Refractory cardiogenic shock, no surgical options
2	Postcardiotomy left ventricular failure	17	Further treatment in EC	Transport with V-A ECMO and IABP	Perioperative death (LVAD)
3	Cardiac arrest caused by MI	12	No ICU beds available at tertiary centre		Withdrawal of therapy because of persistent cardiogenic shock and anoxic encephalopathy
4	Hypovolemic shock caused by bleeding pancreatic tumour	11	Further treatment in EC		During transfer from patient bed to transport trolley a massive rebleeding occurred, after discussion with intensivist from local hospital transport was cancelled
5	Cardiogenic shock after MI and CPR	12	Further treatment in EC	IABP (placed by MICU team)	Withdrawal of therapy because of MOF and poor preadmission performance
6	Cardiogenic shock after MI with RF	7	Further treatment in EC	Transport on NIV	Refractory cardiogenic shock
7	MOF/severe liver failure	20	Further treatment in EC		PEA due to MOF
8	CPR due to VF	10	No ICU beds available at local hospital		Withdrawal of therapy because of poor neurological prognosis and poor preadmission performance
9	Severe mitral valve insufficiency	14	Further treatment in EC		Refractory cardiogenic shock, no surgical options
10	Postcardiotomy left ventricular failure	15	Further treatment in EC	Transport with V-A ECMO and IABP	Perioperative death (LVAD)
11	CPR due to hypoxaemia	8	No ICU beds available at local hospital	10 min delay before BLS	Withdrawal of therapy because of poor neurological status with brainstem dysfunction
12	Traumatic brain injury	15	Further treatment in trauma centre		Withdrawal of therapy because of severe traumatic brain injury with brainstem dysfunction, no surgical options
13	Respiratory failure after aspiration MRSA+	12	No isolation bed available at local ICU (MRSA patient)	6 h treatment at isolation box on general ward at local hospital with MICU equipment by MICU/local ICU team	Unless maximum therapy further deterioration occurred, patient died due to refractory hypoxaemia
14	MOF due to legionella pneumonia	17	Further treatment in EC		PEA due to MOF

BLS, basic life support; CPR, cardiopulmonary resuscitation; EC, expertise centre; IABP, intra-aortic balloon counter pulsation; ICU, intensive care unit; LVAD, left ventricular assist device; MI, myocardial infarction; MICU, mobile intensive care unit; MOF, multiorgan failure; MRSA, methicillin-resistant *Staphylococcus aureus*; NIV, non-invasive ventilation; PEA, pulse less electric activity; RF, respiratory failure; SOFA, Sequential Organ Failure Assessment; V-A ECMO, veno-arterial ECMO; VF, ventricular fibrillation.

So, do we need specialised retrieval teams and what parameters should we use to determine the quality of a transport facility?

Belway et al[19] concluded in a systematic review in 2006, that current data are insufficient to determine whether the use of specialist transport personnel improves patient outcome. Moreover, also in 2006, Fan et al[20] concluded in a systematic review that insufficient data exist to draw firm conclusions regarding the mortality, morbidity or risk factors associated with the interfacility transport.

In general, proxy parameters, critical event rate, number of physiological parameters beyond a predefined threshold or short-term mortality, are used and studies using these parameters suggest that specialised retrieval teams perform better.[8 9 21 22] In this study, short-term mortality and short-term morbidity was analysed by monitoring SOFA scores directly, before and 24 h after transport; this is a potentially practical parameter. Nevertheless, we agree with the conclusions of Fan et al, and doubt whether the aforementioned parameters sufficiently reflect quality of interhospital transport.

A lot of non-transport-related factors interfere with short-term morbidity and certainly with short-term mortality.[23–25] However, what does a decrease in oxygen saturation below a certain threshold mean if we do not see this in the context of the severity of the patient's lung failure?

The incidence of critical events during transportation of patients varies in the literature. It is important, however, to emphasise that there is no clear standard definition for adverse events during transportation. Fanara et al[1] described a critical event rate for intrahospital transport of up to 68%, with serious adverse events ranging between 4.2% and 8.9%. Wiegersma et al[9] report a critical event rate for interhospital transport of 12.5% due to technical problems, but without the need for immediate intervention. Uusaro et al[26] reported no major medical or technical complications during interhospital transport of severely hypoxic patients. An analysis of 191 mechanical-ventilated patients undergoing rotary wing transport showed that 22% of the patients experienced a minor event.[27] In our study, a critical event rate of 6.4% was found which appears in line with current literature.

The question rises as to whether the 4.1% 24 h mortality in the present study was influenced by transport-related factors. The pretransport data of these non-survivors as compared with the survivors showed higher SOFA scores, lower pH, higher age, the frequent use of vasoactive/inotropic medication, more cardiac diagnoses and more often transport with short-term cardiac assist devices. Since there were no differences between the two groups of patients in the number of critical events or other transport-related parameters, but a significant difference concerning severity of illness, we conclude that mainly the pre-existing clinical status was responsible for the difference in mortality between the two groups, and that the contribution of the transport per se was limited. Certainly, the low number of patients in the non-survivor group makes it difficult to draw meaningful conclusions. Moreover, knowledge on the physiological impact of transportation on critically ill patients is scarce and possible factors that may contribute are yet unknown.

There are several limitations to the present paper. This study is a descriptive analysis of a single-centre database with a limited number of patients and with only one post-transport data set (SOFA score) 24 h after MICU transport. Owing to the single-centre character of the study in a certain region of the Netherlands, selection bias cannot be ruled out. Moreover, transportation was carried out by a dedicated, well-trained retrieval team in a fully equipped ambulance which might not be available in many other centres or countries, and limits generalisability.

Although these data are not specific enough to answer the question of which patient will benefit from being transported and how to monitor quality of interhospital transport, our results do suggest that there are certain patient characteristics indicating a high risk for short-term mortality and that measuring short-term outcome appears useful to determine whether there is a negative transport-related effect on the patients' clinical condition.

CONCLUSION

Interhospital transport of intensive care patients performed by a specialised retrieval team with advanced ICU equipment in the South East of the Netherlands has no negative effect on short-term (24 h) outcomes. Short-term (24 h) mortality after MICU transport appears mainly influenced by the natural course of critical illness and decisions to retain further aggressive therapy in individual patients. More research is required, data on stratification of patients who will benefit from transportation and the development of a system that enables evaluation of the quality of transportation seem most urgent.

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