www.jpeds.com • THE JOURNAL OF PEDIATRICS

Adverse Events and Associated Factors During Intrahospital Transport of Newborn Infants

Romaine Delacrétaz, MD[1,2], Céline J. Fischer Fumeaux, MD, PhD[2], Corinne Stadelmann, RN[2], Adriana Rodriguez Trejo, PhD[3], Alice Destaillats, MSc[3], and Eric Giannoni, MD[2]

Objective To determine the frequency, type, and severity of adverse events (AEs) during intrahospital transport of newborn infants and to identify associated factors.

Study design We conducted a prospective observational study in a tertiary care academic neonatal unit. All patients hospitalized in the neonatal unit and undergoing intrahospital transport between June 1, 2015, and May 31, 2017 were included. Transports from other hospitals and the delivery room were not included.

Results Data from 990 intrahospital transports performed in 293 newborn infants were analyzed. The median postnatal age at transport was 13 days (Q1-Q3, 5-44). Adverse events occurred in 25% of transports (248/990) and were mainly related to instability of cardiovascular and respiratory systems, agitation, and temperature control. Adverse events were associated with no harm in 207 transports (207/990, 21%), mild harm in 37 transports (37/990, 4%), and moderate harm in 4 transports (4/990, 0.4%). There was no severe or lethal adverse event. Hemodynamic support with catecholamines, the presence of a central venous catheter, and a longer duration of transport were independent predictors for the occurrence of adverse events during transport.

Conclusions Intrahospital transports of newborns are associated with a substantial proportion of adverse events of low-to-moderate severity. Our data have implications to inform clinical practice, for benchmarking and quality improvement initiatives, and for the development of specific guidelines. *(J Pediatr 2022;240:44-50)*.

Hospitalized newborn infants may require intrahospital transport for diagnostic or therapeutic procedures that are not feasible at the bedside. Transport represents a potentially unstable environment. The challenge for the healthcare team is to weigh the risks and benefits of the procedures requiring transport and ensure the best possible care during transport.

Adverse events (AEs), including life-threatening complications, occur during intrahospital transport of critically ill adults and children. Up to 80% of intrahospital transports are associated with AEs such as desaturation, agitation, hemodynamic instability, arrhythmia, hypothermia, and equipment-related problems.[1-9] Critically ill patients requiring mechanical ventilation, sedation, or hemodynamic support are at the greatest risk of developing AEs.[1,3,5] Studies performed in adults and children have led to the development of standardized procedures and guidelines related to pretransport stabilization, training, organization, staffing, medication, and equipment.[10-13] However, due to the specificities of neonatal care and the lack of relevant literature, newborn infants have been excluded from these recommendations.

Given the gaps in the current state of knowledge on intrahospital transport of neonates and the potential for improvement of care in this field, we performed a prospective study to evaluate the frequency of AEs during intrahospital transport of newborn infants and to identify potential risk factors. We also assessed the physiological changes occurring during intrahospital transports of mechanically ventilated newborns.

Methods

We conducted a prospective observational study in the 40-bed tertiary care medical and surgical neonatal unit of the University Hospital of Lausanne, Lausanne, Switzerland. The neonatal unit has 12 intensive care beds, 16 intermediate care beds, and 12 specialized care beds. The study was approved by the Cantonal Ethics Committee of Vaud (Lausanne, Switzerland). The need for informed consent was waived due to the observational nature of the study.

Infants hospitalized in the neonatal unit who underwent intrahospital transport between June 1, 2015, and May 31, 2017 were eligible for the study.

AE	Adverse event
FiO_2	Fraction of inspired oxygen
SpO_2	Peripheral oxygen saturation

From the [1]Department of Pediatrics, eHnv Yverdon-les-Bains, Yverdon-les-Bains; and [2]Department Mother-Woman-Child, Clinic of Neonatology, Clinic of Neonatology and [3]Mother-Child Research Unit, Department Mother-Woman-Child, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland

The authors declare no conflicts of interest.

https://doi.org/10.1016/j.jpeds.2021.08.074

An intrahospital transport was defined as a transport outside the neonatal unit, but within the hospital for a diagnostic or therapeutic intervention. For patients who underwent multiple transports, each transport was considered a separate event. Transports from the delivery room to the neonatal unit, as well as ambulance or helicopter transports were excluded from the study.

All patients were transported by the staff of the neonatal unit. Physicians and nurses working in the neonatal unit receive specific training regarding transport and equipment used for transport and are implicated in both intra- and interhospital transports. The number and type of professionals and equipment involved in each transport were decided on an individual basis by the caregivers.

Data Collection

Healthcare professionals present during the transport collected data through a case report form. Information concerning the patient's demographics and clinical characteristics, the transport (indication, date, duration, destination, number, and type of staff involved, medical devices, and treatments), AEs, and interventions was recorded. Heart rate, oxygen saturation (SpO_2), and the fraction of inspired oxygen (FiO_2) were collected within 5 minutes before and after the transport, with an additional measure during transport for patients that had continuous monitoring of vital signs. Additional data were obtained from electronic medical charts and through the clinical information system Metavision (iMDsoft).[14,15]

Statistical Analyses

AEs were defined as any event considered by healthcare givers as a danger for the health of the newborn or vital signs displaying values outside reference ranges. Desaturation was defined by a SpO_2 <85% for infants born preterm (<37 weeks of gestation) and a SpO_2 <92% for infants born at term (≥37 weeks of gestation); hypothermia was defined by a temperature <36°C, and hyperthermia was defined by a temperature >38°C; bradycardia was defined by a heart rate <90/min for infants born preterm and <80/min for infants born at term; tachycardia was defined by a heart rate >180/min; hypotension was defined by mean arterial blood pressure less than corrected or postmenstrual age, and hypertension was defined by a systolic blood pressure >95 mm Hg for infants born at term and >85 mm Hg for infants born preterm.[16-19] We defined complicated transports as transports with at least 1 AE.

Every complicated transport was classified according to the World Health Organization, depending on the level of harm[20]: (1) no harm: the patient outcome is not symptomatic or no symptoms are detected and no treatment is required; (2) mild harm: the patient outcome is symptomatic, symptoms are mild, loss of function or harm is minimal or intermediate but short term, and no or minimal intervention (eg, extra observation, investigation, review or minor treatment) is required; (3) moderate harm: the patient outcome is symptomatic, requiring intervention (eg, additional operative procedure; additional treatment), an increased length of stay, or causing permanent or long-term harm or loss of function; (4) severe harm: the patient outcome is symptomatic, requiring life-saving intervention or major surgical/medical intervention, shortening life expectancy or causing major permanent or long-term harm or loss of function; and (5) death: on the balance of probabilities, death was caused or brought forward in the short term by the incident.

The severity of each AE was established by 4 investigators. Each investigator independently reviewed every AE and rated its severity depending on the level of harm.[20] In case of discordance in the rating of an event, the investigators discussed in a focus group to reach a consensus.

Baseline clinical characteristics were described using the median and the first and third quartiles (Q1-Q3) for continuous variables, and absolute and relative frequencies for categorical variables. For continuous data, differences between groups with and without AEs were analyzed using a parametric test (t test for normally distributed data), or a nonparametric test (Wilcoxon rank-sum test). For categorical data, the Pearson χ^2 test (or Fisher exact test when expected cell frequencies were <5) was used. To analyze potential predictors of AEs during transports, a generalized estimating equation was used to account for the correlation ie, present in the data (repeated transports for the same individuals). Vital signs were measured before, during, and after transport. We performed generalized linear mixed models to assess a possible effect of time on vital signs and possible differences between groups with and without AEs. These models analyzed differences at time points during and after transport from the initial time point (before transport), within each complication group, and the comparisons between groups at each time point, with adjustment for all comparisons. Two-sided paired t tests were used, and the statistical significance was defined as $P < .05$. We performed statistical analyses with R version 4.0.2 (R Foundation for Statistical Computing).

Results

Of the 1555 patients admitted to the neonatal unit of the University Hospital of Lausanne during the study period, 371 patients (24%) underwent 1402 transports. Nine hundred ninety (990/1402, 71%) transports performed in 293 infants had adequate documentation and could be included in the study. Baseline characteristics of transports that could and could not be included have been reported (R. Delacrétaz et al, unpublished data, 2021).

Patient Characteristics

The median gestational age of the transported infants was 38 weeks (Q1-Q3 34-39), and the median birth weight was 2560 g (Q1-Q3 1595-3210) (**Table I**). The most common reasons for hospital admission were prematurity (105/293, 36%), congenital malformations (69/293, 24%), and asphyxia or seizures (44/293, 15%).

Table I. Clinical characteristics and outcomes of patients with and without AEs during transport

Clinical characteristics and outcomes	All patients n = 293	Patients with AE n = 132	Patients without AE n = 161	P value*
Female sex, No. (%)	118 (40)	49 (37)	69 (43)	.38
Median gestational age, wk (Q1-Q3)	38 (34-39)	36 (30-39)	38 (35-39)	<.001
Preterm newborns, No. (%)	132 (45)	72 (25)	60 (20)	.005
Median birth weight, g (Q1-Q3)	2560 (1595-3210)	2265 (1108-3140)	2740 (1960-3300)	<.001
Median 1-minute Apgar score (Q1-Q3)	7 (3-9)	6 (3-9)	7 (3-9)	.19
Median 5-minute Apgar score (Q1-Q3)	9 (6-9)	8 (6-9)	9 (7-10)	.09
Median 10-minute Apgar score (Q1-Q3)	9 (8-10)	9 (8-10)	9 (8-10)	.14
Congenital malformations, No. (%)	69 (24)	32 (24)	37 (23)	1.00
Median number of transports per patients (Q1-Q3)	2 (2-4)	4 (2-6)	2 (2-2)	<.001
Median duration of hospital stay, d (Q1-Q3)	16 (8-46)	27 (14-82)	10 (6-23)	<.001
Death, No. (%)	11 (4)	7 (5)	4 (2)	.23

*P values from χ^2 test (or Fisher exact test) for categorical variables and from Wilcoxon test for continuous variables.

Transport Characteristics

Median postnatal age and weight at the time of transport were 13 days (Q1-Q3 5-44) and 2960 g (Q1-Q3 2380-3460) (Table II). Indications for transport included magnetic resonance imaging (280/990, 28%), ultrasound scan (186/990, 19%), surgery (118/990, 12%), return from surgery (89/990, 9%), bronchoscopy (77/990, 8%), computed tomography (62/990, 6%), and other indications (173/990, 17%), including gastrointestinal contrast studies and voiding cystourethrograms.

Table II. Main characteristics of transports with or without AEs

Variables	All transports n = 990	Transports with AE n = 248	Transports without AE n = 742	P value*
Median postnatal age at the time of transport, d (Q1-Q3)	13 (5-44)	22 (7-64)	11 (4-38)	<.001
Median weight at the time of transport, g (Q1-Q3)	2960 (2380-3460)	2900 (2270-3470)	2985 (2420-3460)	.85
Reason for transport				<.001
Magnetic resonance imaging, n (%)	280 (28)	59 (24)	221 (30)	
Ultrasound scan, No. (%)	186 (19)	23 (9)	163 (22)	
Surgery, No. (%)	118 (12)	38 (15)	80 (11)	
Return from surgery, No. (%)	89 (9)	41 (17)	48 (6)	
Bronchoscopy, No. (%)	77 (8)	32 (13)	45 (6)	
Computed tomography, No. (%)	62 (6)	15 (6)	47 (6)	
Other† No. (%)	173 (17)	40 (16)	133 (18)	
Median duration of transport, min (Q1-Q3)	10 (8-12)	10 (10-15)	10 (8-11)	<.001
Median number of caregivers present during transport (Q1-Q3)	2 (1-2)	2 (2-3)	2 (1-2)	<.001
Respiratory support				<.001
Invasive ventilation, No. (%)	169 (17)	75 (30)	94 (13)	
Noninvasive ventilation, No. (%)	120 (12)	48 (19)	72 (10)	
Nasal canulae, No. (%)	91 (9)	24 (10)	67 (9)	
Vascular access				
Peripheral venous catheter, No. (%)	463 (47)	128 (52)	335 (45)	.09
Central venous catheter,‡ No. (%)	360 (36)	132 (53)	228 (31)	<.001
Arterial catheter,§ No. (%)	92 (9)	32 (13)	60 (8)	.03
Gastric tube,¶ No. (%)	665 (67)	193 (78)	472 (64)	<.001
Bladder catheter, No. (%)	71 (7)	31 (13)	40 (5)	<.001
Other medical device,** No. (%)	13 (1)	6 (2)	7 (1)	.15
Vasoactive drugs,†† No. (%)	57 (6)	29 (12)	28 (4)	<.001
Sedative and analgesics,‡‡ No. (%)	179 (18)	76 (31)	103 (14)	<.001
Transport vehicle				<.001
Incubator, No. (%)	310 (31)	103 (42)	207 (28)	
Stroller, No. (%)	301 (30)	38 (15)	263 (35)	
Radiant warmer, No. (%)	136 (14)	43 (17)	93 (13)	
MR Diagnostics Incubator System Nomag, No. (%)	127 (13)	34 (14)	93 (13)	
Crib/bed, No. (%)	94 (9)	22 (9)	72 (10)	
Other,§§ No. (%)	2 (0.2)	0	2 (0)	

MR, magnetic resonance.
*P values from χ^2 test for categorical variables, and from Wilcoxon test for continuous variables.
†Including gastrointestinal contrast studies, voiding cystourethrograms, and other indications.
‡Including umbilical venous catheters, peripherally inserted central catheters, and other central venous catheters.
§Including umbilical and peripheral arterial catheters.
¶Includes gastric and duodenal tubes.
**Including peritoneal drainage, chest tube, and colostomy.
††Continuous infusion of catecholamines and/or prostaglandins.
‡‡Continuous infusion only.
§§Transports on the mother using a scarf.

Table III. Type of AEs and estimated level of harm

AEs	All transports,* n = 990	Complicated transports with no harm,*† n = 207	Complicated transports with mild harm,*† n = 37	Complicated transports with moderate harm,*† n = 4
Hypotension	64 (6)	51 (5)	12 (1)	1 (0.1)
Tachycardia	62 (6)	56 (6)	6 (1)	0 (0)
Agitation	45 (5)	43 (4)	2 (0.2)	0 (0)
Desaturation	44 (4)	39 (4)	3 (0.3)	2 (0.2)
Hypertension	40 (4)	40 (4)	0 (0)	0 (0)
Hypothermia	28 (3)	0 (0)	26 (3)	2 (0.2)
Hyperthermia	20 (2)	13 (1)	7 (0.7)	0 (0)
Equipment problem	14 (1)	11 (1)	1 (0.1)	2 (0.2)
Bradycardia	7 (1)	6 (1)	1 (0.1)	0 (0)
Pain	5 (1)	5 (1)	0 (0)	0 (0)
Apnea	2 (0.2)	2 (0.2)	0 (0)	0 (0)

*The total number of transports included in the study was used as a denominator.
†The level of harm associated with each complicated transport was defined by the study investigators after reviewing each case, according to the World Health Organization classification[18] as described in the Methods.

AEs

Overall, 25% (248/990) of all transports were associated with AEs (Table III). The severity of AEs was considered as no harm in 207 of 990 (21%) transports, mild in 37 of 990 (4%), and moderate in 4 of 990 (0.4%). The following AEs were observed during the 4 transports associated with moderate harm: 2 mechanically ventilated newborns who were late preterm and term with congenital malformations had an acute and profound desaturation requiring manual ventilation during preoperative transfer; an infant who was late preterm under therapeutic hypothermia for perinatal asphyxia developed accidental hypothermia (29.5°C) during transport from radiology to the neonatal unit after a magnetic resonance imaging; and a newborn who was extremely preterm returning to the neonatal unit after surgical closure of the ductus arteriosus developed hypothermia (34°C) in the operating room and was still hypothermic during transport. No AE was considered as severe, and no death occurred due to transport.

Clinical Variables Associated with AEs during Transport

Patients who underwent complicated transports had a lower gestational age and lower birth weight, a greater number of transports per patient, and a longer duration of hospital stay compared with those who were transported without AEs (Table I). In univariate analysis, the reason for transport, a greater postnatal age, longer transports, transports under respiratory or hemodynamic support, use of continuous infusions of sedatives/analgesics were associated with AEs (Table II). Medical devices including central venous catheter, arterial catheter, gastric tube, and bladder catheter, a greater number of caregivers, and the type of equipment used to transport the newborns were also associated with AEs during transport.

Duration of transport (z score = 2.56, $P = .01$), presence of a central venous catheter (z score = −3.76, $P < .001$), and hemodynamic support with vasoactive drugs (z score = −2.66, $P = .008$) were independent predictors of AEs. For an increase in the duration of transport of 1 minute, an infant was 4% more likely to have a complication when holding all other variables equal. On average, infants with a central venous catheter and vasoactive drugs were 39% and 37% more likely to have an AE during transport compared with infants who did not have those devices or drugs (R. Delacrétaz et al, unpublished data, 2021).

Vital Signs in Patients under Mechanical Ventilation

Heart rate, SpO_2, and FiO_2 were measured before, during, and after transport in 80 critically ill newborns transported under mechanical ventilation (Figure) (R. Delacrétaz et al, unpublished data, 2021). Transport was not associated with significant changes in heart rate and SpO_2. In comparison with values measured before transport, FiO_2 decreased during and after transport, leading to an increase in SpO_2/FiO_2 ratio during and after transport. Patient heart rate before, during, and after transport, and SpO_2 before transport were not different between uncomplicated and complicated transports. In contrast, SpO_2 during and after transport was lower in complicated transports, and FiO_2 before, during, and after transport was higher in complicated transports. This resulted in a lower SpO_2/FiO_2 ratio before, during, and after transport in complicated transports.

Discussion

Intrahospital transports of newborn infants are frequent, and a substantial proportion is associated with AEs of low-to-moderate severity. The main clinical variables associated with AEs are a requirement for hemodynamic support with vasoactive drugs, the presence of a central venous catheter, and a longer duration of transport.

Hospitalized newborn infants are a vulnerable population who experience 20-30 iatrogenic complications per 1000 patient days.[21,22] Transports may introduce additional hazards related to the underlying condition requiring transport, movement of the patient, equipment, and team. AEs were relatively frequent in our study. Yet, the rate of complicated transports (25%) is at the low end of previous reports (25%-

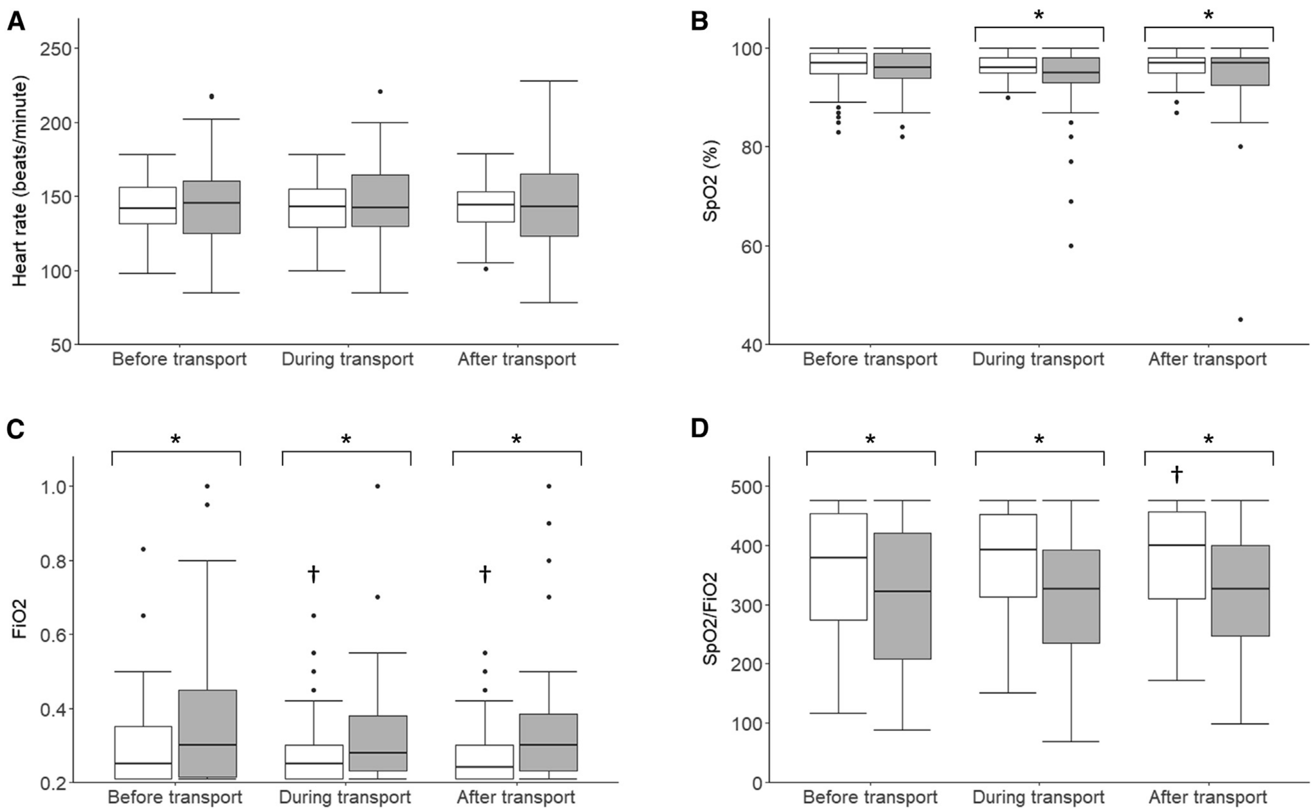

Figure. A, Heart rate; **B,** SpO_2; **C,** FiO_2; and **D,** SpO_2/FiO_2 before, during, and after transport in patients transported under mechanical ventilation. Data from transports with (n = 75, *gray boxes*) and without (n = 94, *white boxes*) AEs are presented. **P* < .05. †*P* < .05 compared with values before transport.

80%) in adults, children, and newborns.[1-7,11,23–25] In contrast to studies performed in children and adults, we did not observe any transport-related life-threatening or fatal AEs such as cardiac arrest or unplanned extubation.[9,11] AEs were mainly related to instability of the cardiovascular and respiratory systems, agitation, and temperature control. Newborn infants are vulnerable to unintentional hypothermia, which can occur during surgical procedures or diagnostic studies performed outside the neonatal unit, and during transport.[24] The proportion of neonates who underwent accidental hypothermia during intra-hospital transport is lower in our study (3%) than the 12%-27% reported in the literature.[23,26,27] The proportion of equipment-related AEs in our study (1%) is lower than previously reported in neonates, children, and adults (5%-34%).[7,23,25] This suggests that accidental hypothermia and equipment-related AEs are potentially avoidable.

Transport of critically ill adults and children is associated with physiological deterioration, including changes in heart rate, blood pressure, respiratory rate, and oxygen saturation.[7,25,28] In our cohort, infants requiring mechanical ventilation did not have changes in heart rate or worsening of oxygenation due to transport. This suggests that, under appropriate conditions of staffing and equipment, most newborn patients can be transported without physiologic deterioration.

Critically ill adult and pediatric patients transported during mechanical ventilation or hemodynamic support are at the greatest risk of AEs.[1,3,5,9] We found that hemodynamic support with catecholamines or prostaglandins, and the presence of a central venous catheter were strongly associated with AEs. The proportion of complicated transports was greater in infants transported under noninvasive or invasive ventilation compared with those who did not require respiratory support. Mechanically ventilated infants who developed AEs during transport had a lower SpO_2/FiO_2 ratio before, during, and after transport, reflecting greater severity of underlying lung disease. Yet, respiratory support was not an independent predictor of AEs in our cohort.

Infants born preterm are at high risk of iatrogenic complications.[21,22] Fragility and functional limitations of developing organs, the requirement for support with invasive medical devices, and prolonged hospital stay may contribute to the vulnerability of infants born preterm to AEs during medical care. In our study, median gestational age and birth weight was lower in patients with complicated transports compared with those with uncomplicated transports. However, the association between lower gestational age and birth weight and the occurrence of AEs during intrahospital transport was not statistically significant in multivariate analysis. Overall, the duration of transport was relatively short in our study, but longer transports were associated with AEs, consistent with previous studies.[7,23] However, we cannot conclude whether a longer duration of transport was the cause or the consequence of AEs in our cohort, and the difference in duration of transport between complicated and uncomplicated transports is unlikely to be clinically relevant.

Guidelines for intrahospital transports exist for adults and children[10,11,13] but are lacking for newborn infants. Despite being a very common procedure, literature on intrahospital transport of newborn infants is scarce.[23,26,27] A recent systematic review analyzed 24 studies reporting on AEs during intrahospital transport of critically ill children.[9] These publications described AEs occurring during transport across all pediatric age groups but with little neonatal data. Of 7 studies including only newborns, 5 focused on specific age groups (preterm),[29–31] conditions (necrotizing enterocolitis),[32] indications for transport (surgery, imaging, transport from the delivery room),[24,29,30] and/or outcomes (hypothermia, desaturation).[29–31] Only 2 studies, from middle-income countries, reported on all intrahospital transports in the entire neonatal population.[23,26] They found that AEs were frequent and were mainly related to hypothermia. Respiratory support and transport for surgery were the main risk factors.

Interhospital transport of critically ill newborn infants from regional hospitals to tertiary care neonatal units is abundantly discussed in the literature.[33] Specific recommendations exist regarding the organization, team skills, and training, equipment, and procedures required for interhospital transport of newborns.[34–36] The existence of such recommendations and the expertise acquired during interhospital transport are likely to benefit intrahospital transports when they are conducted by the same teams. However, the clinical scenarios requiring intrahospital transport (such as the immediate postoperative period) are different from those requiring interhospital transport and warrant the development of specific guidelines.

Several limitations should be acknowledged. The study was conducted at a single hospital site, and therefore the results may not be generalizable. In particular, the lower rate of AEs observed compared with children or adult studies could be at least partially linked to the use of specific material and the relative high expertise in transport of our team. Twenty-nine percent of all transports could not be analyzed due to incomplete data. Although the main demographic characteristics of the transports that could not be analyzed were in the same range as those of the analyzed transports, we cannot rule out selection bias. We could not determine which proportion of AEs was related to the transport itself rather than the underlying condition of the patient and/or the diagnostic or therapeutic procedure performed before transport and did not determine the long-term impact of transport on neonates. It is unclear which proportion of the observed AEs may be avoidable. However, given that intrahospital transport is a common procedure and that important differences in the occurrence of specific AEs were observed within studies, we speculate that quality improvement initiatives may play an important role to mitigate the risks of transport in newborn infants.

Neonates transported within the hospital can experience AEs. The severity of illness and duration of transport are associated with AEs and should be considered when planning a procedure out of the neonatal unit. The benefits of such procedures must be weighed against the anticipated risk of AEs, and the possibility to perform the procedure at the bedside. Pretransport stabilization and selection of the appropriate staff and equipment are essential to reduce the risk of AEs and their consequences. Future guidelines on neonatal transport should include a section on intrahospital transport. ■

We thank the nursing and medical staff from the neonatal unit of the University Hospital of Lausanne for their contribution to data collection. Eric Giannoni is supported by the Leenaards Foundation.

Submitted for publication Apr 13, 2021; last revision received Aug 19, 2021; accepted Aug 25, 2021.

Reprint requests: Eric Giannoni, MD, Service de Néonatologie, Département femme-mère-enfant, Centre Hospitalier Universitaire Vaudois, Avenue Pierre Decker 2, CH-1011 Lausanne, Switzerland. E-mail: Eric.Giannoni@chuv.ch

References

1. Lahner D, Nikolic A, Marhofer P, Koinig H, Germann P, Weinstabl C, et al. Incidence of complications in intrahospital transport of critically ill patients—experience in an Austrian University Hospital. Wien Klin Wochenschr 2007;119:412-6.
2. Lovell MA, Mudaliar MY, Klineberg PL. Intrahospital transport of critically ill patients: complications and difficulties. Anaesth Intensive Care 2001;29:400-5.
3. Damm C, Vandelet P, Petit J, Richard JC, Veber B, Bonmarchand G, et al. Complications during the intrahospital transport in critically ill patients. Ann Fr Anesth Reanim 2005;24:24-30 [in French].
4. Beckmann U, Gillies DM, Berenholtz SM, Wu AW, Pronovost P. Incidents relating to the intra-hospital transfer of critically ill patients. An analysis of the reports submitted to the Australian Incident Monitoring Study in Intensive Care. Intensive Care Med 2004;30:1579-85.
5. Parmentier-Decrucq E, Poissy J, Favory R, Nseir S, Onimus T, Guerry MJ, et al. Adverse events during intrahospital transport of critically ill patients: incidence and risk factors. Ann Intensive Care 2013;3:10.
6. Voigt LP, Pastores SM, Raoof ND, Thaler HT, Halpern NA. Review of a large clinical series: intrahospital transport of critically ill patients: outcomes, timing, and patterns. J Intensive Care Med 2009;24:108-15.
7. Wallen E, Venkataraman ST, Grosso MJ, Kiene K, Orr RA. Intrahospital transport of critically ill pediatric patients. Crit Care Med 1995;23:1588-95.
8. Schwebel C, Clec'h C, Magne S, Minet C, Garrouste-Orgeas M, Bonadona A, et al. Safety of intrahospital transport in ventilated critically ill patients: a multicenter cohort study*. Crit Care Med 2013;41:1919-28.
9. Haydar B, Baetzel A, Elliott A, MacEachern M, Kamal A, Christensen R. Adverse events during intrahospital transport of critically ill children: a systematic review. Anesth Analg 2020;131:1135-45.
10. Quenot JP, Milesi C, Cravoisy A, Capellier G, Mimoz O, Fourcade O, et al. Intrahospital transport of critically ill patients (excluding newborns) recommendations of the Societe de Reanimation de Langue Francaise (SRLF), the Societe Francaise d'Anesthesie et de Reanimation (SFAR), and the Societe Francaise de Medecine d'Urgence (SFMU). Ann Intensive Care 2012;2:1.
11. Fanara B, Manzon C, Barbot O, Desmettre T, Capellier G. Recommendations for the intra-hospital transport of critically ill patients. Crit Care 2010;14:R87.
12. Brunsveld-Reinders AH, Arbous MS, Kuiper SG, de Jonge E. A comprehensive method to develop a checklist to increase safety of intra-hospital transport of critically ill patients. Crit Care 2015;19:214.

13. Warren J, Fromm RE Jr, Orr RA, Rotello LC, Horst HM , American College of Critical Care Medicine. Guidelines for the inter- and intrahospital transport of critically ill patients. Crit Care Med 2004;32:256-62.
14. Levesque E, Hoti E, Azoulay D, Ichai P, Samuel D, Saliba F. The implementation of an Intensive Care Information System allows shortening the ICU length of stay. J Clin Monit Comput 2015;29:263-9.
15. Duvoisin G, Fischer C, Maucort-Boulch D, Giannoni E. Reduction in the use of diagnostic tests in infants with risk factors for early-onset neonatal sepsis does not delay antibiotic treatment. Swiss Med Wkly 2014;144: w13981.
16. Stranak Z, Semberova J, Barrington K, O'Donnell C, Marlow N, Naulaers G, et al. International survey on diagnosis and management of hypotension in extremely preterm babies. Eur J Pediatr 2014;173: 793-8.
17. Tarnow-Mordi W, Kirby A. Current recommendations and practice of oxygen therapy in preterm infants. Clin Perinatol 2019;46:621-36.
18. Kent AL, Kecskes Z, Shadbolt B, Falk MC. Normative blood pressure data in the early neonatal period. Pediatr Nephrol 2007;22:1335-41.
19. Pejovic B, Peco-Antic A, Marinkovic-Eric J. Blood pressure in non-critically ill preterm and full-term neonates. Pediatr Nephrol 2007;22: 249-57.
20. World Health Organization. The Conceptual Framework for the International Classification for Patient Safety (ICPS). 2010. Accessed April, 17, 2020, https://www.who.int/patientsafety/implementation/taxonomy/ICPS-report/en/.
21. Ligi I, Arnaud F, Jouve E, Tardieu S, Sambuc R, Simeoni U. Iatrogenic events in admitted neonates: a prospective cohort study. Lancet 2008;371:404-10.
22. Kugelman A, Inbar-Sanado E, Shinwell ES, Makhoul IR, Leshem M, Zangen S, et al. Iatrogenesis in neonatal intensive care units: observational and interventional, prospective, multicenter study. Pediatrics 2008;122:550-5.
23. Vieira AL, dos Santos AM, Okuyama MK, Miyoshi MH, de Almeida MF, Guinsburg R. Factors associated with clinical complications during intra-hospital transports in a neonatal unit in Brazil. J Trop Pediatr 2011;57:368-74.
24. Don Paul JM, Perkins EJ, Pereira-Fantini PM, Suka A, Farrell O, Gunn JK, et al. Surgery and magnetic resonance imaging increase the risk of hypothermia in infants. J Paediatr Child Health 2018;54:426-31.
25. Jia L, Wang H, Gao Y, Liu H, Yu K. High incidence of adverse events during intra-hospital transport of critically ill patients and new related risk factors: a prospective, multicenter study in China. Crit Care 2016;20:12.
26. Bastug O, Gunes T, Korkmaz L, Elmali F, Kucuk F, Adnan Ozturk M, et al. An evaluation of intra-hospital transport outcomes from tertiary neonatal intensive care unit. J Matern Fetal Neonatal Med 2016;29: 1993-8.
27. Vieira AL, Santos AM, Okuyama MK, Miyoshi MH, Almeida MF, Guinsburg R. Predictive score for clinical complications during intra-hospital transports of infants treated in a neonatal unit. Clinics (Sao Paulo) 2011;66:573-7.
28. Zuchelo LT, Chiavone PA. Intrahospital transport of patients on invasive ventilation: cardiorespiratory repercussions and adverse events. J Bras Pneumol 2009;35:367-74.
29. Benavente-Fernandez I, Lubian-Lopez PS, Zuazo-Ojeda MA, Jimenez-Gomez G, Lechuga-Sancho AM. Safety of magnetic resonance imaging in preterm infants. Acta Paediatr 2010;99:850-3.
30. Harer MW, Vergales B, Cady T, Early A, Chisholm C, Swanson JR. Implementation of a multidisciplinary guideline improves preterm infant admission temperatures. J Perinatol 2017;37:1242-7.
31. Hu XJ, Wang L, Zheng RY, Lv TC, Zhang YX, Cao Y, et al. Using polyethylene plastic bag to prevent moderate hypothermia during transport in very low birth weight infants: a randomized trial. J Perinatol 2018;38: 332-6.
32. Frawley G, Bayley G, Chondros P. Laparotomy for necrotizing enterocolitis: intensive care nursery compared with operating theatre. J Paediatr Child Health 1999;35:291-5.
33. Diehl BC. Neonatal transport: current trends and practices. Crit Care Nurs Clin North Am 2018;30:597-606.
34. Whyte HE, Jefferies AL. Canadian Paediatric Society, Fetus and Newborn Committee. The interfacility transport of critically ill newborns. Paediatr Child Health 2015;20:265-75.
35. Stroud MH, Trautman MS, Meyer K, Moss MM, Schwartz HP, Bigham MT, et al. Pediatric and neonatal interfacility transport: results from a national consensus conference. Pediatrics 2013;132:359-66.
36. Insoft RM, Schwartz HP, Romito J. Guidelines for air and ground transport of neonatal and pediatric patients. Itasca (IL): American Academy of Pediatrics; 2015.