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RESEARCH ARTICLE

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A standard operating procedure for prehospital anaesthesia and its effect on mortality—An observational study

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Abstract

Background: Prehospital anaesthesia is a complex intervention performed for critically ill patients. To minimise complications, a standard operating procedure (SOP) outlining the process is considered valuable. We investigated the implementation of an SOP for prehospital anaesthesia in helicopter emergency medical services (HEMS).

Methods: We performed a retrospective observational study of patients receiving prehospital anaesthesia by Finnish HEMS from January 2012 to August 2019. The intervention studied was the implementation of an SOP at two of the five bases during 2015–2016. Patients were stratified according to whether they were anaesthetised before, during or after implementation and the primary outcomes were 1- and 30-day mortality. Secondary outcomes included anaesthesia quality indicators. Confounding factors was assessed via logistic regression.

Results: A total of 3902 tracheal intubations were performed without an SOP, 430 during implementation and 1525 after implementation. The SOP had a significant effect on 1-day mortality during implementation with an odds ratio (OR) of 0.56, 95% confidence interval (95% CI) 0.37–0.81 and a further trend towards benefit after implementation (OR 0.84, 95% CI 0.68–1.04), but no difference in 30-day mortality (OR after implementation 1.10, 95% CI 0.92–1.30). Implementation of an SOP improved first-pass success rate from 87.3% to 96.5%, $p < 0.001$.

Conclusion: Implementation of an SOP for prehospital anaesthesia was associated with a trend towards lower 1-day mortality and an improved first-pass success but did not affect 30-day mortality. Despite this, we advocate prehospital systems to consider implementation of a prehospital anaesthesia SOP as immediate performance markers improved significantly.

KEYWORDS
air ambulances, airway management, critical care, emergency medical services, rapid sequence induction and intubation

Editorial Comment

This retrospective observational study of the Finnish national Helicopter Emergency Medical Services (HEMS) database examined the effect of a standardised operating procedure (SOP) for pre-hospital anaesthesia on 1- and 30-day mortality. The SOP was introduced in two (implementation) out of five (three control) HEMS between 2012 and 2019. The SOP implementation was associated with reduced 1-day mortality but did not change 30-day mortality. This is an important finding as improved 1-day mortality is an absolute prerequisite for any benefit to be gained from subsequent improvements of in-hospital treatment.

1 | INTRODUCTION

Critically ill patients in the prehospital setting receiving anaesthesia have a high risk of mortality.[1] The quality of treatment of these patients has improved substantially in recent years due to, among other factors, highly trained personnel,[2] limiting critical interventions to fewer units to allow for higher case volumes,[3] new monitoring modalities, new equipment and new drugs.[4] Although each detail is important on its own, it has been shown that overarching standard operating procedures (SOP) and bundles of interventions provide positive results regarding success rates and frequency of complications.[5,6] Focusing solely on improving one small detail such as laryngoscopy disregards a large majority of the complex process.[7] Prehospital anaesthesia is only one part of the patient's journey, and there are a vast number of factors influencing the outcome.[7]

Factors relating to intubation performance, such as first-pass success (FPS), have been linked to improved peri-intubation physiology.[8–10] However, while improving success rates, few individual interventions show any beneficial effect on long-term outcomes. This is the case for SOPs and bundles of interventions as well; studies linking their use to survival benefits are, to our knowledge, non-existent. As the SOP studied here is a comprehensive and complex guideline,[11] it influences the whole process from the first unit arriving on scene until hospital handover and, therefore, should logically have a larger impact on patient care during the whole prehospital process.[7]

In this study, we wanted to examine the effect of an SOP for prehospital anaesthesia on 1- and 30-day mortality, hypothesising that as the SOP comprehensively affects so many aspects of prehospital care, it would improve even a broad outcome such as mortality. We further wanted to study how the implementation of an SOP affected other quality indicators of prehospital anaesthesia.

2 | METHODS

2.1 | Study design

We performed a retrospective observational cohort study of adult patients receiving prehospital anaesthesia by helicopter emergency medical services (HEMS) from 1 January 2012, through 31 August 2019. Helsinki University Hospital's ethical committee and all registry data owners approved the study protocol. Data access was granted by all hospitals responsible for HEMS (Oulu University Hospital 200/2019 2.7.2019, Helsinki University Hospital HUS/280/2019 9.7.2019, Turku University Hospital J30/19 4.8.2019, Hospital District of Lapland 32/2019 22.8.2019, Kuopio University Hospital RPL 102/2019 22.8.2019 and Tampere University Hospital RTL-R19580 2.9.2019), the Finnish Institute for Health and Welfare (THL/2231/5.05.00/2019) and the Digital and Population Data Services Agency (VRK/5613/2019 3). The study did not affect patient treatment, and therefore informed consent was not required. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement is followed in the reporting of this study.[12]

2.2 | Setting

The setting of this study was the national HEMS system in the country of Finland. Finland is part of the Nordic countries in the northern part of Europe and is a sparsely populated country with 5.55 million inhabitants. Healthcare in Finland is based on a single-payer system, and therefore is almost free of charge with a high quality of care. This is also true for the prehospital system; anyone in need can call the national emergency response centre and incur no cost. The emergency units (healthcare, fire, police and social services) are then dispatched according to nationally unified criteria. The HEMS units are included in this system and dispatched, either by the dispatch centre or later upon request by other units, to patients who are thought to benefit from prehospital critical care. These patients include, among others, those suffering from out-of-hospital cardiac arrest (OHCA), major trauma or unconsciousness.

The emergency medical services (EMS) personnel in Finland consist of healthcare professionals evaluated and supervised by local administrative prehospital physicians. Nationally, EMS units are typically staffed by at least one paramedic nurse with a bachelor's degree in prehospital emergency care or a registered nurse with 1 year of additional education for prehospital emergency care, and accompanied by a registered nurse, a practical nurse or a firefighter. The Finnish national HEMS system consists of six units covering most of the country. Five of the units are staffed by physicians and one unit in northern Finland is staffed by paramedics. Most of the HEMS physicians are senior anaesthesiologists with substantial experience in airway management and prehospital emergency medicine.

2.3 | Data sources

The Finnish national HEMS database, described extensively in an earlier publication, provided the data.[13] Data recorded on prehospital airway management follow the internationally established guidelines.[14] The database underwent minor revisions during the study period which affected some of the data collection, especially regarding the secondary outcomes.[13] Data extracted underwent no secondary validation or evaluation of accuracy. The survival rates of the patients were analysed with data from the population registry using personal identification numbers that are issued to all citizens in Finland.

2.4 | Participants

We included all cases of prehospital anaesthesia and therefore excluded tracheal intubations performed during cardiac arrest. The data do include tracheal intubations performed after return of spontaneous circulation, categorised as OHCA in the results. Tracheal intubations by the northernmost HEMS unit were excluded due to a differing staffing composition that was deemed not comparable. The sample was then stratified into three groups: (1) tracheal intubations by a HEMS unit not utilising an SOP for prehospital anaesthesia; (2) tracheal intubations by a HEMS unit during the implementation phase of an SOP for prehospital anaesthesia; and (3) tracheal intubations by a HEMS unit utilising an SOP for prehospital anaesthesia. The second group was included as the SOPs were gradually implemented over a long period of time, during which tracheal intubations were done both with and without an SOP guiding the process.

2.5 | Variables

The exposure studied was whether an SOP for prehospital anaesthesia was implemented at the HEMS base at the time of the patient treatment. The primary outcomes were 1- and 30-day mortality. The secondary outcomes included process-related outcomes and physiological surrogate endpoints: on-scene time, intubation first-pass success, hypoxia after intubation, hypotension after intubation, hypoxia at the time of handover at the hospital and normoventilation achieved at patient handover at the hospital. The definitions for physiological outcomes followed the international consensus recommendation on quality indicators for prehospital anaesthesia: hypoxia after intubation defined as a decrease in oxygen saturation below 90% or ≥10% from baseline, hypotension after intubation defined as a decrease in systolic blood pressure below 90 mmHg or ≥10% from baseline, hypoxia at handover defined as an oxygen saturation below 90%, and normoventilation at handover defined in patients with traumatic brain injury as an $EtCO_2$ of 4–4.67 kPa and in all other patients as 4.67–6.67 kPa.[15]

The confounding factors used in the multivariable logistic regression were age, sex, time from the alarm to reaching the patient, patient category and vital signs at first encounter which included systolic blood pressure, heart rate, oxygen saturation and Glasgow coma scale (GCS). Factors were chosen a priori, based on available data, existing literature that present their association with mortality and expert opinion.[16–19] Of the available variables, we decided not to control for respiratory rate as it is often missing and or inaccurate.[20] The duration of transport was also omitted as it is correlated with time from alarm to patient and unlikely to provide any additional value.

2.6 | Intervention

The intervention was the use of an SOP for prehospital anaesthesia by physician-staffed HEMS. Two HEMS units out of five implemented an SOP for prehospital anaesthesia during the study period in 2015 and 2016, and the SOPs were largely similar in composition. The SOP is a complex entity, conceived using existing literature and expert opinion. It comprises much more than just the laryngoscopy and intubation as it dictates several actions from the dispatch to the handover at the hospital.[21,22] Furthermore, the SOP does not only concern the work carried out by the HEMS unit but also guides the preparations performed by the EMS units already on scene.

Key features of the SOP cover the preparation, pre-induction, intubation and post-intubation care. Anaesthesia is induced mainly with esketamine and with obligatory use of the neuromuscular blocking agent (NMBA) rocuronium. Propofol and fentanyl are used in specific cases, such as status epilepticus, where the seizure activity needs dampening, and also in traumatic brain injury, where hypertension is to be avoided. To maximise the possibility of first-pass success, laryngoscopy and intubation are standardised and performed with the use of a video laryngoscope and a bougie. The SOP also dictates the thresholds for aborting an intubation attempt and interventions to be performed in the case of a failed first intubation attempt or an unsuccessful intubation.[23] After successful airway management, the SOP favours mechanical ventilation. Specific parts of the process involves checklists to be followed, including preparations done by the ambulance crew before HEMS arrival, steps for anaesthesia induction, and procedures to complete before transport to hospital is to begin. The SOP also standardises the roles within the crew and the communication between team members. As the SOP attempts to standardise and define the whole prehospital phase of the patient, the implementation process has also been extensive. Utilising many different educational modalities, the SOP was implemented to the local EMS and HEMS community over a period of several months.[22]

The control group consisted of the physician-staffed HEMS units not using a comprehensive SOP for prehospital anaesthesia. However, it is important to recognise that the anaesthesia and intubation performed by these units still maintained a high standard, highlighted by the overall high success rate and low frequency of complications in the system.[24] The units without an SOP were able to use the same actions and equipment as in the SOP, albeit not in a similarly standardised fashion, as the care was mostly dictated individually by the physician on scene. Equipment and methods available developed

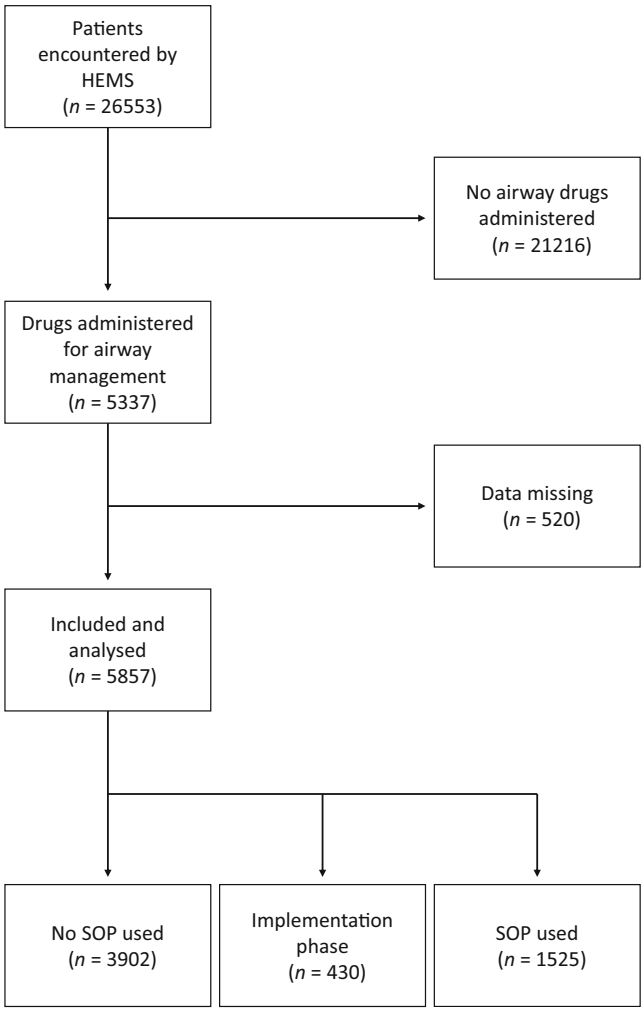

FIGURE 1 Flowchart of patient selection. HEMS, Helicopter emergency medical services; SOP, Standard operating procedure.

substantially over the study period regardless of SOP implementation. For example, at the end of the period, advanced equipment such as video laryngoscopes and bougies were available and checklists for prehospital anaesthesia were implemented in most units.

2.7 | Statistical methods

Visual analysis of distributions revealed virtually all variables to have a non-normal distribution; hence we used nonparametric tests and reported data as median (interquartile range) for continuous variables and number (percentages) for proportions. The groups were compared using Chi-square and Kruskal–Wallis tests, as appropriate. Multivariate logistic regression was used to analyse the association between the use of an SOP and mortality, both 1 and 30 days. Age, sex, systolic blood pressure, heart rate, oxygen saturation, GCS, delay from alarm to scene and patient category were used as covariates. The association of available covariates with outcome was tested using univariate logistic regression analysis. We conducted a sensitivity analysis that included all feasible covariates that showed an association with the outcomes in univariate analyses. Goodness-of-fit of the models were assessed using Nagelkerke's R^2. Cases with missing data regarding either outcome or covariates were excluded from the analyses. To assess for possible bias introduced by missing data, we performed a sensitivity analysis using multiple imputation.

We evaluated the potential for a trend in mortality by studying the annual mortality visually, both overall and stratified by bases that implemented an SOP during study period. We also constructed similar multivariate logistic regression models as above but with the year the intervention was performed instead of whether an SOP was used as covariable. A p-value <0.05 was determined to be statistically significant. All statistical analyses were done using *R*, version 4.3.2 for x86_64-apple-darwin20 (R Core Team, Vienna, Austria).

3 | RESULTS

A total of 5857 patients underwent prehospital anaesthesia and were included in the study. Of these, 3902 (66.7%) were treated without an SOP, 430 (7.3%) during the implementation phase and 1525 (26.0%) with an SOP implemented (Figure 1). Baseline characteristics were largely similar between groups, and patients treated after SOP implementation were slightly younger and had a shorter delay from emergency call to HEMS patient contact (Table 1).

3.1 | Treatment of the patients

The use of a combination of anaesthetic and NMBA in the induction was more frequent during implementation, $n = 404$ (94%), and when using the SOP, $n = 1452$ (95.2%), compared to patients treated without the SOP, $n = 3401$ (87.2%), $p < 0.001$. Mechanical ventilation showed the same association and was used more often in the implementation and SOP groups ($n = 396$, 92.1% and $n = 1438$, 94.3%) compared to the non-SOP group ($n = 2762$, 70.8%), $p < 0.001$. Use of vasoactive drugs were also lower during the implementation phase, $n = 228$ (53.0%), and with the use of an SOP, $n = 750$ (49.2%) than when treated without an SOP, $n = 2242$ (57.5%), $p < 0.001$.

3.2 | Mortality

Survival data were available for 3735 (95.7%) patients treated without the SOP, for 412 (97.9%) treated during implementation and for 1438 (94.3%) treated with the SOP. In the whole sample overall, 871 (15.6%) patients died within 1 day of the incident and 1803 (32.2%) within 30 days of the incident.

Complete data regarding mortality and all covariables in the regression model were available for 4612 (78.7%) patients. The unadjusted 1-day mortality was significantly lower in the patients treated during implementation, 41/421 (9.7%) and with the SOP, 193/1438 (13.4%) compared to the patients treated without an SOP, 637/3735

TABLE 1 Characteristics of the patients undergoing prehospital anaesthesia without a standard operating procedure (SOP) for prehospital anaesthesia, during implementation of an SOP and with an SOP in use.

	No SOP used $n = 3902$		Implementation phase $n = 430$		SOP used $n = 1525$		Missing data, n (%) $n = 5857$	
Sex, male	2535	(65.4)	271	(63.0)	986	(64.8)	29	(0.50)
Age, years	60	(41–71)	57	(39–69)	54	(32–68)	1	(0.02)
HEMS at patient, minutes from call	24	(16–37)	21	(16–30)	21	(16–29)	1224	(20.9)
Patient categories								
OHCA	780	(20.0)	88	(20.5)	349	(22.9)	0	(0)
Trauma	943	(24.2)	109	(25.3)	368	(24.1)		
Neurological	1333	(34.2)	132	(30.7)	450	(29.5)		
Intoxication	464	(11.9)	61	(14.2)	272	(17.8)		
Other	382	(9.8)	40	(9.3)	86	(5.6)		
Vital signs upon HEMS crew arrival to the patient								
Heart rate (beats.min^{-1})	91	(75–115)	98	(80–117)	97	(76–117)	647	(11.0)
Systolic blood pressure (mmHg)	132	(110–162)	134	(110–162)	134	(110–161)	716	(12.2)
Oxygen saturation (%)	96	(90–98)	96	(92–98)	97	(93–99)	879	(15.0)
Glasgow coma scale	4	(3–6)	4	(3–7)	3	(3–6)	112	(1.9)

Note: Categorical data are presented as n (%) and continuous data as median (25–75th percentiles).
Abbreviations: HEMS, Helicopter emergency medical services; OHCA, Out-of-hospital cardiac arrest (intubated after return of spontaneous circulation).

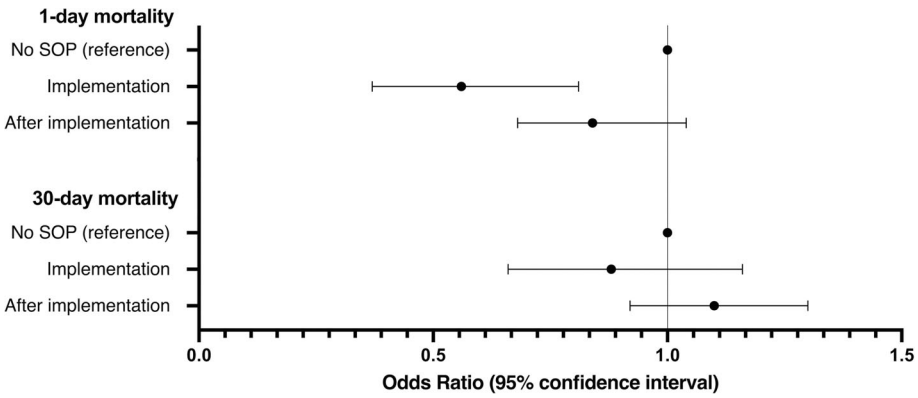

FIGURE 2 The results of two multivariate logistic regression analysis studying the effect of the use of a standard operating procedure (SOP) for prehospital anaesthesia using 1- and 30-day mortality as outcomes. Both adjusted for age, sex, systolic blood pressure, heart rate, oxygen saturation, Glasgow coma scale, delay from alarm to scene and patient category.

(17.1%), $p < 0.001$ The difference was also observed in the multivariable analysis using 1-day mortality as outcome: odds ratio (OR) for the implementation phase was 0.56, 95% confidence interval (95% CI) 0.37–0.81 and OR with the use of an SOP was 0.84, 95% CI 0.68–1.04, with the group not using an SOP as reference (Figure 2). Nagelkerke's R^2-value for the model was 0.21.

Regarding 30-day mortality the findings were not found to be significant, neither unadjusted nor adjusted. The 30-day mortality was 123/421 (29.2%) during implementation of the SOP, 443/1438 (30.8%) with the use of an SOP and 1237/3735 (33.1%) without an SOP, $p = 0.11$. Adjusting by using the same model as for 1-day mortality provided the following results: OR for the implementation phase was 0.88, 95% CI 0.66–1.16 and OR with the use of an SOP was 1.10, 95% CI 0.92–1.30, with the group not using an SOP as reference (Figure 2). The model had a Nagelkerke's R^2-value of 0.34.

A slightly decreasing annual trend in 1-day mortality and an increase in 30-day mortality was observed. The trends were similar in both groups but overall mortality was lower in the units that implemented an SOP during the study period (Tables S1 and S1). However, no statistical significance was found between the year the intervention was performed and mortality in the multivariable regression (Table S1).

We performed a sensitivity analysis accounting for missing data using multiple imputation. This produced similar results to our main model (Table S2). All of the covariates that were chosen for the main multivariate logistic regression analysis were associated with 1-day and 30-day mortality in univariate logistic regression analysis (Tables S3 and S3). In addition to chosen covariates, respiratory rate showed an association with 1- and 30-day mortality. A sensitivity analysis including it as a covariate yielded similar results to our primary analysis (Tables S3 and S3).

3.3 | Secondary outcomes

The process-related and surrogate outcome measures also showed significant differences between the groups (Table 2). Intubation FPS

TABLE 2 Process-related and surrogate outcomes in patients undergoing prehospital anaesthesia with and without standard operating procedure (SOP).

	No SOP used $n = 3902$		Implementation phase $n = 430$		SOP used $n = 1525$		p-value	Missing data, n (%) $n = 5857$	
On-scene time	30	(21–42)	30	(22–40)	30	(23–40)	0.79	5	(0.1)
Intubation first pass success	2003	(87)	393	(92)	1204	(96)	<0.001	1888	(32)
Hypoxia post-intubation	31	(1.7)	10	(3.1)	32	(2.8)	0.071	2480	(42)
Hypotension post-intubation	122	(3.5)	17	(4.1)	57	(3.9)	0.71	2843	(48)
$SpO_2 \geq 90\%$ at time of handover	3375	(97)	406	(98)	1420	(97)	0.19	501	(8.6)
Normoventilation at time of handover	2324	(78)	329	(78)	1064	(71)	<0.001	950	(16)

Note: Categorical data are presented as *n* (%) and continuous data as median (25–75th percentiles).

rate improved from 87.3% without an SOP, through 92.0% during the implementation phase, to 96.5% after implementation ($p < 0.001$). Normoventilation at patient handover at the hospital was achieved more likely in the non-SOP group. The rates of hypoxia and hypotension immediately following induction of anaesthesia was low in both groups. High proportions of missing data were seen regarding FPS and post-intubation vital signs, mostly because recording of these variables did not begin until 2014.[13]

4 | DISCUSSION

4.1 | Main findings

In this study of patients undergoing prehospital anaesthesia by HEMS, the implementation of a comprehensive SOP for prehospital anaesthesia was associated with a trend towards lower 1-day mortality but did not have a significant effect on 30-day mortality. SOP implementation was also associated with improved secondary system performance and quality of care-related outcomes; first-pass success, the combined use of anaesthetics and NMBA, use of mechanical ventilation and a less frequent need for vasoactive drugs. On the other hand, to our surprise, we simultaneously found lower rates of normoventilated patients at handover after SOP implementation despite increasing use of mechanical ventilation. No previous studies looking at the effect of an SOP implementation for prehospital anaesthesia on mortality exist to our knowledge, and despite the negative results regarding 30-day mortality, the data presented here support previous findings of the beneficial effects of SOPs and bundle of interventions on improvement of system performance and patient outcomes.[25–27]

4.2 | Interpretation and clinical relevance

The results outline the importance of performing prehospital anaesthesia on critically ill patients systematically and to a high standard, as the intervention carries with it numerous challenges ranging from deranged patient physiology to varying team compositions. The trend towards lower 1-day mortality and higher FPS suggest that these challenges could be met by performing prehospital anaesthesia according to a pre-established protocol. The desired protocol would encompass not just a single piece of equipment or technique, but the entire prehospital team and prehospital care, even in the context of experienced physician providers. The clear beneficial association with 1-day mortality during implementation but not after implementation is curious. This could be explained in part by the Hawthorne effect: That humans modify their behaviour in response to the awareness of being observed.[28] The mere attention the implementation draw to the intervention and the continuous audits and support given during this time could have influenced the HEMS teams.[22] However, measured by quality indicators like FPS and on-scene time the high performance has been sustained for several years at one of the SOP units.[22]

Although lacking association with 30-day mortality, we still consider 1-day mortality a relevant outcome for the study. Even if it can be argued that from the patient perspective it is irrelevant whether they survive the first day or if they die within the first month. 30-day mortality is an outcome much more susceptible to confounding factors of in-hospital management, which could not be accounted for in this retrospective study, whereas 1-day mortality is more likely to be dependent on the quality of the initial prehospital management. Secondly, as the patients were primarily severely ill or injured, the long-term mortality might be mostly dependent on the initial pathology and in-hospital interventions and not on skilfully performed prehospital procedures and high-level prehospital care. Still, improved prehospital anaesthesia management has feasible potential to improve longer-term survival as well, even though this study may have been inadequate to show it. Mortality as an outcome is further not as patient centred as quality of life or neurological outcome would be, but unfortunately we did not have these data available. As complications increase with multiple attempts at tracheal intubation, it seems logical that a significantly higher FPS would be beneficial regarding more patient-centred outcomes like survival.[8–10] In our study, the immediate post-intubation physiological outcomes were similar in all groups, failing to demonstrate this association. Data on these variables were frequently missing in the critical first 2 years of the study period, and these data could possibly have strengthened the trend regarding FPS and shown the benefit regarding complications.

However, if these results can be achieved by mere checklists, or any other single part of the SOP, or if a full-scale SOP is needed, cannot be concluded based on the current study. A checklist for prehospital anaesthesia is an instrumental part of an SOP, but an SOP is a much more comprehensive entity, allowing the whole team including the paramedics to anticipate the steps in the process much earlier rather than ad hoc prior to the procedure. The rationale of a full-scale SOP implementation for prehospital anaesthesia may depend on the context, as it requires a considerable investment of time and resources. When considering implementation of an SOP, it is of utmost importance to know the anaesthesia-quality indicators of the system, such as intubation first-pass success and complication rates.[15,29] Extreme care should be taken when attempting generalisation and adoption of the results from this study into other systems, especially if other quality markers are unknown or weaker.[26]

4.3 | Future directions

It would be valuable to gain further knowledge from a prospective study on the effect of implementation of an SOP for prehospital anaesthesia, especially regarding more patient-centred outcomes such as long-term functional capability while, if possible, also adjusting properly for in-hospital treatment. From the perspective of the EMS personnel, it might be interesting to explore the effect of an SOP implementation on provider experience of situational awareness and workload by means of qualitative research.

4.4 | Strengths

The strengths of the study include a prospective nationwide database containing extensive information on all HEMS missions during the study period. The quality of the data has been previously shown to be high with a small amount of missing data.[30] As there is only one HEMS service operating nationally, the database can be considered to include a very high proportion of patients relevant to the study. Although few studies have the possibility to examine long-term mortality, the Finnish healthcare system makes this possible with unique identification numbers for all citizens that allow for extensive database linkage between different registers and a low number of patients lost to follow-up.

4.5 | Limitations

This study is not without limitations. The data are entered manually into the database by the physician managing the case and are not validated after entry, increasing susceptibility to different biases, especially considering the retrospective study design. Data on post-intubation vital signs and FPS were often missing, mostly due to not being recorded for the first 2 years of the study period, and therefore the results may be biased. However, this would still not affect the main analysis and primary outcome. In addition, the introduction of an SOP may have affected the reporting of complications, as documentation and data collection was highlighted during implementation. Implementation of an SOP included several interventions both in the HEMS service and beyond, but these were not standardised between the units. Implementation of an SOP made the process of prehospital intubation more straightforward and emphasised, so much that it may have changed the clinical indications for prehospital anaesthesia, resulting in disparity between the patient sub-cohorts before and after implementation. The implementation of the SOP and its favourable results received national coverage and might have affected the non-SOP units as well, encouraging individual physicians to perform anaesthesia in a similar fashion. This would have biased our results to show a lesser effect of the implementation.

5 | CONCLUSIONS

Implementation of an SOP for prehospital anaesthesia was associated with a trend towards lower 1-day mortality and improved intubation first-pass success rate but did not affect 30-day mortality. Despite absent association with 30-day mortality in our study, we advocate that prehospital systems use quality indicators to measure their anaesthesia performance and to consider whether this performance could be improved by an extensive SOP.

AUTHOR CONTRIBUTIONS

H.L., J.P., A.S., T.I., H.K. and J.N. contributed to the design of the research. H.L. and A.S. analyzed the data. H.L. drafted the manuscript. J.N. supervised the project. All authors have participated discussing the results and revision on the manuscript.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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