A physiotherapy-led early mobilisation protocol for neurosurgical patients with external ventricular drains in intensive care: A service evaluation

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Abstract

Background

An external ventricular drain (EVD) is used to relieve elevated intracranial pressure in neurosurgical patients, and remains in place for an average of eight days post-surgery. The presence of an EVD poses a major barrier to early mobilisation due to safety concerns. Eligibility criteria published in EVD mobilisation protocols only consisted of parameters related to the neurological system (Moyer et al, 2017; Young et al, 2019). Parameters pertaining to cardiovascular, respiratory and musculoskeletal systems deemed safe for mobilisation were not stated.

Aims

To determine the safety, feasibility and effectiveness of implementing an early mobilisation protocol, which included physiological parameters, in patients with EVDs.

Methods

A retrospective service evaluation was conducted in a neurological intensive care unit. Medical records were reviewed for two periods from October 2017 to March 2018 (pre-protocol period) and October 2019 to March 2020 (protocol period). Eligible patients for out-of-bed mobilisation were screened and identified by physiotherapists.

Results

The results are shown in Table 1. After protocol implementation, there was a 64.8% increase in the proportion of patients with EVDs mobilised (95%CI, 35.9-82.1%, $p<0.0001$). Median time from EVD placement to first mobilisation decreased from 14 to 3.5 days ($p<0.0001$). Moreover, the median intensive care and hospital length of stays were significantly reduced from 8 to 3.5 days ($p=0.037$) and 38 to 22.5 days ($p=0.030$) respectively. No adverse events were recorded in the protocol period.

Conclusion

The early mobilisation protocol for patients with EVDs enabled safe, feasible and effective mobilisation. Future prospective, controlled research studies are warranted.

Table 1. Safety, feasibility and effectiveness of the early mobilisation protocol

	Pre-protocol (n=75)	Protocol (n=42)	Difference with 95% CI (Protocol – Pre-protocol), p-value
Patients eligible for mobilisation, n (%)	25 (33.3%)	16 (38.1%)	
Eligible patients mobilised, n (%) [1]	1 (4%)	11 (68.8%)	64.8%, 95% CI (35.9%, 82.1%), p<0.0001***
Total number of therapy sessions	1	21	
Number of adverse events	Information not available	0	
Time from EVD placement to first mobilisation in the hospital (days) [2]	14.0 (9.5-18.0)	3.5 (2.0-7.0)	p<0.0001***
ICU LOS (days) [2]	8.0 (4.0-10.0)	3.5 (2.0-9.0)	p=0.037***
Hospital LOS (days) [2]	38.0 (24.5-54.5)	22.5 (17.8-39.0)	p=0.030***

Abbreviations: CI = confidence interval; EVD = external ventricular drain; ICU = intensive care unit; LOS = length of stay

*** Level of significance p<0.05

[1]Fisher's exact test

[2]Mann-Whitney U test with median (25^{th}-75^{th} percentile)

Introduction

An external ventricular drain (EVD) is surgically inserted into the brain ventricles to drain cerebrospinal fluid (CSF) and is commonly seen in the neurological intensive care unit (ICU) (Muralidharan, 2015). It is used to relieve raised intra-cranial pressure (ICP) and treat acute hydrocephalus in patients with acquired brain injuries such as traumatic brain injury, intra-cerebral haemorrhage, subarachnoid haemorrhage and meningitis (Muralidharan, 2015), which would otherwise result in reduced cerebral perfusion and increased cerebral oedema (Hinson et al., 2010). This drain also enables clearing of intra-ventricular blood clots, monitoring of ICP and administering of medications.

Historically, patients with EVDs remain on bed rest for the duration of EVD placement (Moyer et al., 2017, Gaspari et al., 2018, Young et al., 2019) which averages eight days (Albano et al., 2018). The presence of an EVD posed a major barrier to early mobilisation as there were safety concerns pertaining to bleeding and dislodgement during the process (Hale et al., 2013). In the event of EVD dislodgement, an emergency surgical procedure would be necessary for re-insertion (Gaspari et al., 2018). As the EVD is clamped to prevent inappropriate drainage of CSF during position changes, there is a potential risk of elevated ICP (Muralidharan, 2015). These factors could deter physiotherapists from encouraging mobilisation. Conversely, eight days on bed rest could have significant negative consequences on the patient's musculoskeletal, cardiovascular and respiratory systems, further prolonging intensive care stay.

Several studies have proposed the use of a mobilisation protocol in the ICU, with eligibility criteria that provide specific safety recommendations to identify suitable

patients (Bailey et al., 2007, Morris et al., 2008, Miranda Rocha et al., 2017). However, most of these were developed and introduced in the medical ICU (Conceição et al., 2017) with only two mobilisation protocols devised particularly for patients with EVDs in the neurological ICU (Moyer et al., 2017, Young et al., 2019). These EVD mobilisation protocols only consisted of exclusion criteria and parameters related to the neurological system. Parameters related to cardiovascular, respiratory and musculoskeletal systems were not clearly stated. The lack of clarity on eligibility criteria could compromise safety and delay mobilisation.

In Tan Tock Seng Hospital (TTSH), Singapore, a physiotherapy-led early mobilisation protocol for neurological patients with EVDs was introduced in April 2018. The protocol contained specific eligibility criteria indicating the parameters for each aforementioned physiological system. The aim of this service evaluation was to determine whether the early mobilisation protocol, which included physiological parameters, was safe, feasible and effective in patients with EVDs.

Methods

Study design and ethical considerations

This was a retrospective service evaluation of an early mobilisation protocol for patients with EVDs in the neurological ICU. Medical records were reviewed for two comparable six-month periods from October 2017 to March 2018 (pre-protocol period) and October 2019 to March 2020 (protocol period). The UCL Research Ethics Committee and Singapore's Domain Specific Review Board granted ethics exemption and waiver of informed consent. Service evaluation registration procedures within the hospital were followed.

ICU setting

Tan Tock Seng Hospital is the second largest public tertiary hospital in Singapore. In the 18-bedded neurological ICU, a typical nurse-to-patient ratio is 1:2. A blanket referral system for physiotherapy is in place, and physiotherapists are allowed to screen and review patients. On weekdays, the workload is shared among two permanent senior physiotherapists and two rotating junior physiotherapists. They provide respiratory and rehabilitation therapy for the patients. On weekends, patients are reviewed by other physiotherapists who are rostered to work for the day, mainly for respiratory interventions.

Protocol

The EVD early mobilisation protocol was devised through discussion with physiotherapists, neurosurgeons and ICU consultants. The term 'early' mobilisation was determined from the time at which the patients were deemed physiologically stable

following a set of inclusion and exclusion criteria, as shown in Tables 1 and 2 respectively. Patients with EVDs were evaluated by physiotherapists on a daily basis to determine their eligibility for mobilisation. As for the type of mobilisation activity performed and the level of assistance given, it was dependent on physiotherapy assessment on the day of therapy.

Table 1. Inclusion criteria

Neurology system	• ICP ≤ 15mmHg (as measured using either Codman ICP transducer or EVD) • GCS of at least E3 and M6 • Left and Right Lindegaard Ratio (MCA/ICA mean flow velocity ratio) ≤ 3 (no vasospasm) • MCA mean flow velocity ≤ 120cm/s (no vasospasm) • RASS -1 to +1
Respiratory system	• PEEP ≤ 8cmH_2O • FiO_2 ≤ 0.5 • RR ≤ 24 breaths per minute • SpO_2 ≥ 95%
Cardiovascular system	• No new onset of arrhythmias or cardiac ischaemia within 12 hours • No vasopressor and inotrope • 40bpm ≤ HR ≤ 120bpm • MAP ≥ 65mmHg
Musculoskeletal system	• Muscle strength ≥ 3/5 using manual muscle testing (at least one sided UL and LL)

Definition of abbreviations: bpm = beats per minute; EVD = external ventricular drain; FiO_2 = fraction of inspired oxygen; GCS = Glasgow Coma Scale; HR = heart rate; ICA = internal carotid artery; ICP = intracranial pressure; LL = lower limb; MAP = mean arterial pressure; MCA = middle cerebral artery; PEEP = positive end-expiratory pressure; RASS = Richmond Agitation Sedation Scale; RR = respiratory rate; SpO_2 = peripheral capillary oxygen saturation, UL = upper limb

Table 2. Exclusion criteria

Others	• Uncontrolled seizures
EVD	• Active bleeding • Blocked • CSF leak • Use of urokinase • EVD height < +5cmH_2O • Hourly drainage >100ml

Definition of abbreviations: CSF = cerebrospinal fluid; EVD = external ventricular drain

Mobilisation was defined as any active out-of-bed activity that consisted of sitting-on-edge-of-bed, sit-to-stand, sitting-out-of-bed, marching and ambulation. The flow chart used to guide mobilisation was modified from Moyer et al (2017) and is illustrated in Figure 1. The physiotherapist assisted the patient in mobilisation while a nurse managed the EVD. The EVD was clamped during mobilisation and levelled to the tragus of the ear to measure ICP before session, sitting-on-edge-of-bed and after session. For higher levels of mobilisation activity, ICP was not measured but vital signs and symptoms were monitored throughout by both the nurse and physiotherapist.

Service evaluation process

Relevant data for the studied time periods were extracted from the hospital's electronic system by the principal investigator and were de-identified. Data were stored in an encrypted Microsoft Excel file. For patients from the pre-protocol period, eligibility for mobilisation was determined by retrospectively reviewing their hourly physiological parameters in the ICU and comparing to the protocol's eligibility criteria. For patients deemed eligible for mobilisation, physiotherapy documentation was further scrutinised to find out whether they were, in fact, mobilised. Data entry was verified by a random check of 10% of patients with an independent physiotherapist who was not part of the project team.

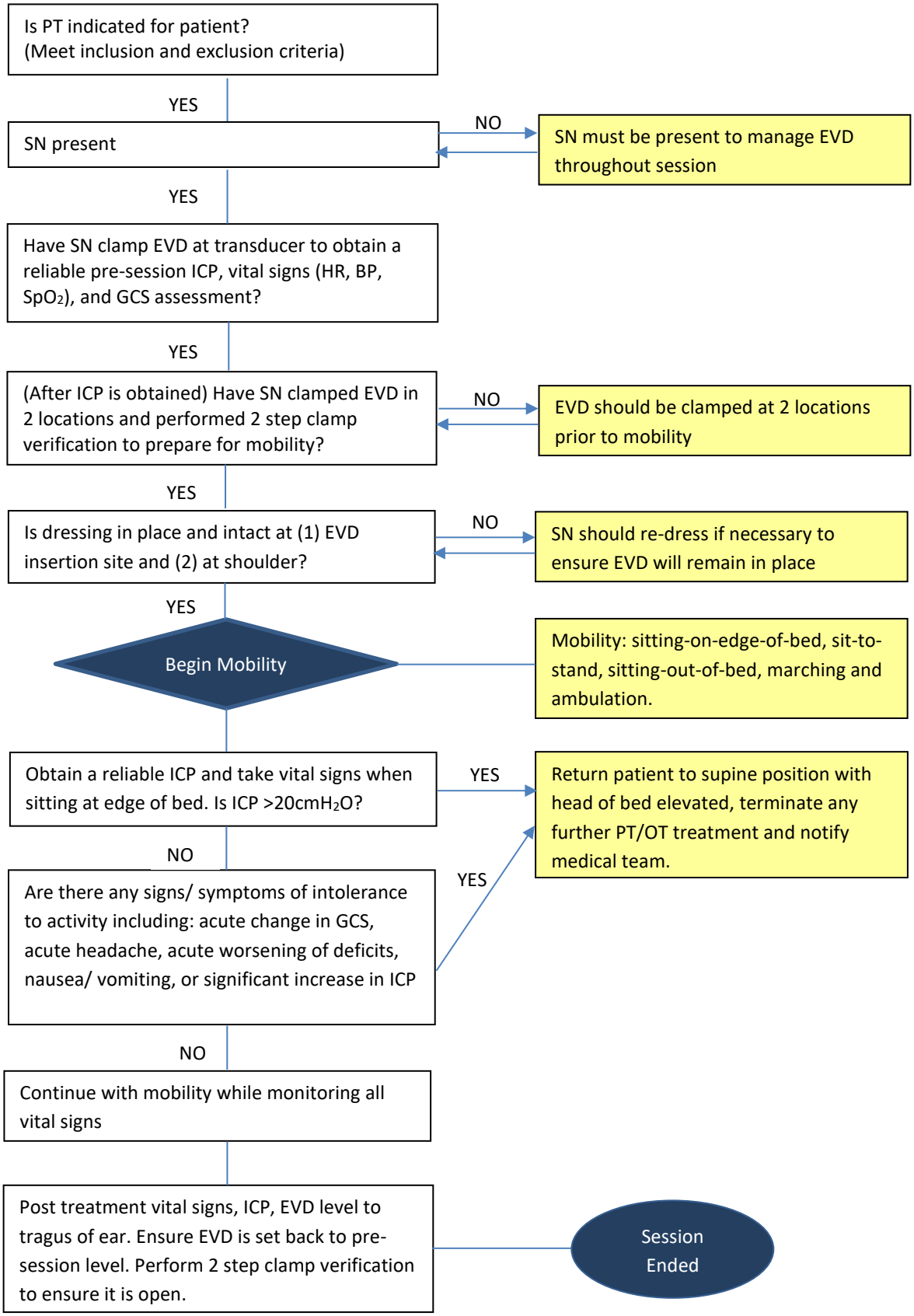

Figure 1. EVD mobilisation flow chart

Outcome measures

Outcome measures for safety, feasibility and effectiveness were collected. Safety was determined by the number and type of adverse events occurring during mobilisation. Adverse events were defined as events exceeding the established safety limits. Types of adverse events included elevated ICP (>20mmHg), EVD dislodgement or malfunction, haemodynamic events (orthostatic systolic blood pressure (BP) drop by ≥20mmHg; hypotension or hypertension depending on patient's baseline BP range and the targeted BP range set by neurosurgeons) and adverse symptoms (such as dizziness, emesis and headache). Adverse events that led to clinical deterioration and the need for medical intervention were termed as "adverse events with consequences". Feasibility was determined by the proportion of patients who were successfully mobilised in the neurological ICU. Effectiveness of the protocol was assessed using the following outcomes: (i) time from EVD placement to first mobilisation in the hospital; (ii) ICU length of stay (LOS); and (iii) hospital LOS, in eligible patients.

Statistical analysis

Data were analysed using the SPSS Windows Version 25.0. Continuous variables were analysed using a two-sample t-test for parametric data or Mann-Whitney U test for non-parametric data. Chi-square test (n>20) or Fisher's exact test (n<20) was used for categorical variables. Level of significance was set at 0.05 for all tests. As significant differences in patient baseline characteristics may influence the outcomes of the protocol, a correlation test was conducted. A Pearson's correlation (r) for parametric data or Spearman's correlation (r_s) for non-parametric data was used for the correlation test.

Results

A total of 75 patients received EVDs during the pre-protocol period (Figure 2) and 42 patients underwent EVD placement in the protocol period (Figure 3). Their eligibility for mobilisation are summarised in Figures 2 and 3. The baseline characteristics of eligible patients for the two periods are shown in Table 3. There were similar baseline characteristics except for the Glasgow Coma Scale (GCS) on emergency department (ED) admission, which was significantly higher in the protocol group (p=0.023).

Safety, feasibility and effectiveness of the early mobilisation protocol are shown in Table 4. After protocol implementation, the median time from EVD placement to first mobilisation decreased from 14 to 3.5 days (p<0.0001) in eligible patients. The median ICU and hospital length of stays were also significantly reduced from 8 to 3.5 days (p=0.037) and 38 to 22.5 days (p=0.030) respectively. Correlation tests between the GCS on ED admission and LOS in both ICU and hospital showed either weak correlation (r_s=0.038 to 0.070, p>0.05) or a clinically unimportant relationship (multiple outliers). Hence, the GCS on ED admission may not influence LOS.

No adverse events were recorded for the 21 mobilisation sessions in the protocol period. The highest level of mobility achieved during each session was sitting-on-edge-of-bed (47.6%), followed by marching (23.8%), sit-to-stand (19.1%) and ambulation (9.5%). Only 1 out of 25 eligible patients was mobilised in the pre-protocol period, compared to 11 out of 16 patients in the protocol period. Reasons for the remaining 5 patients not mobilised are seen in Figure 3. This contributes to a 64.8% (95%CI, 35.9-82.1%, p<0.0001) increase in the proportion of patients mobilised.

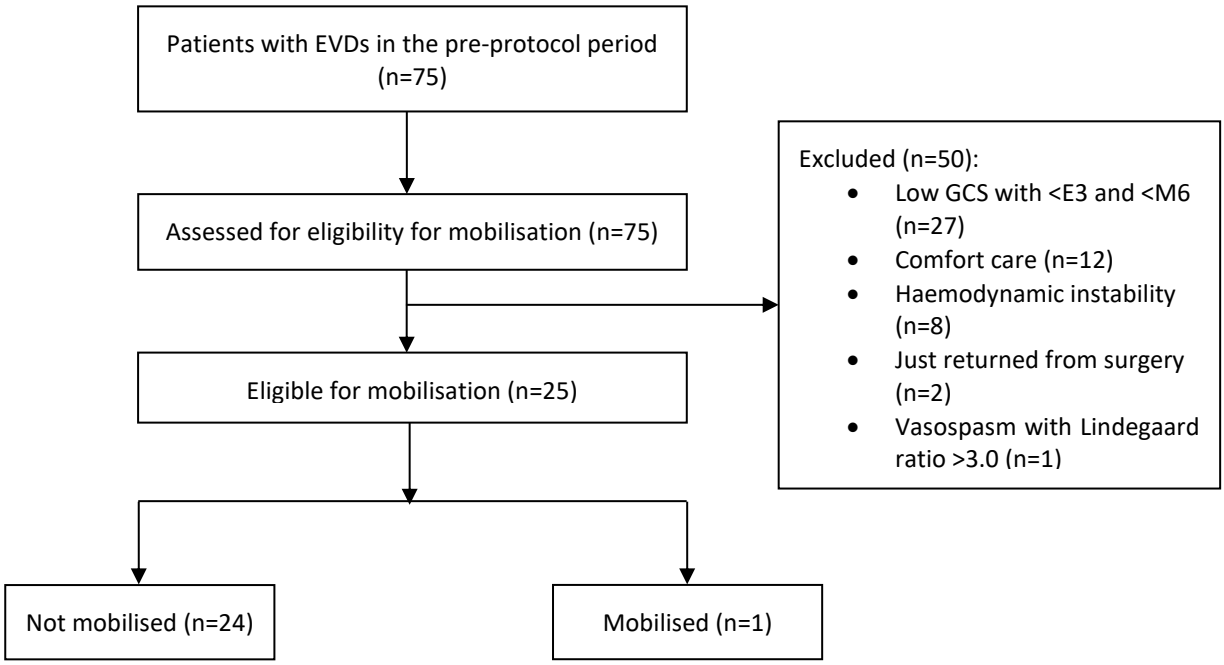

Figure 2. Flow chart for patients' eligibility for mobilisation in the pre-protocol period

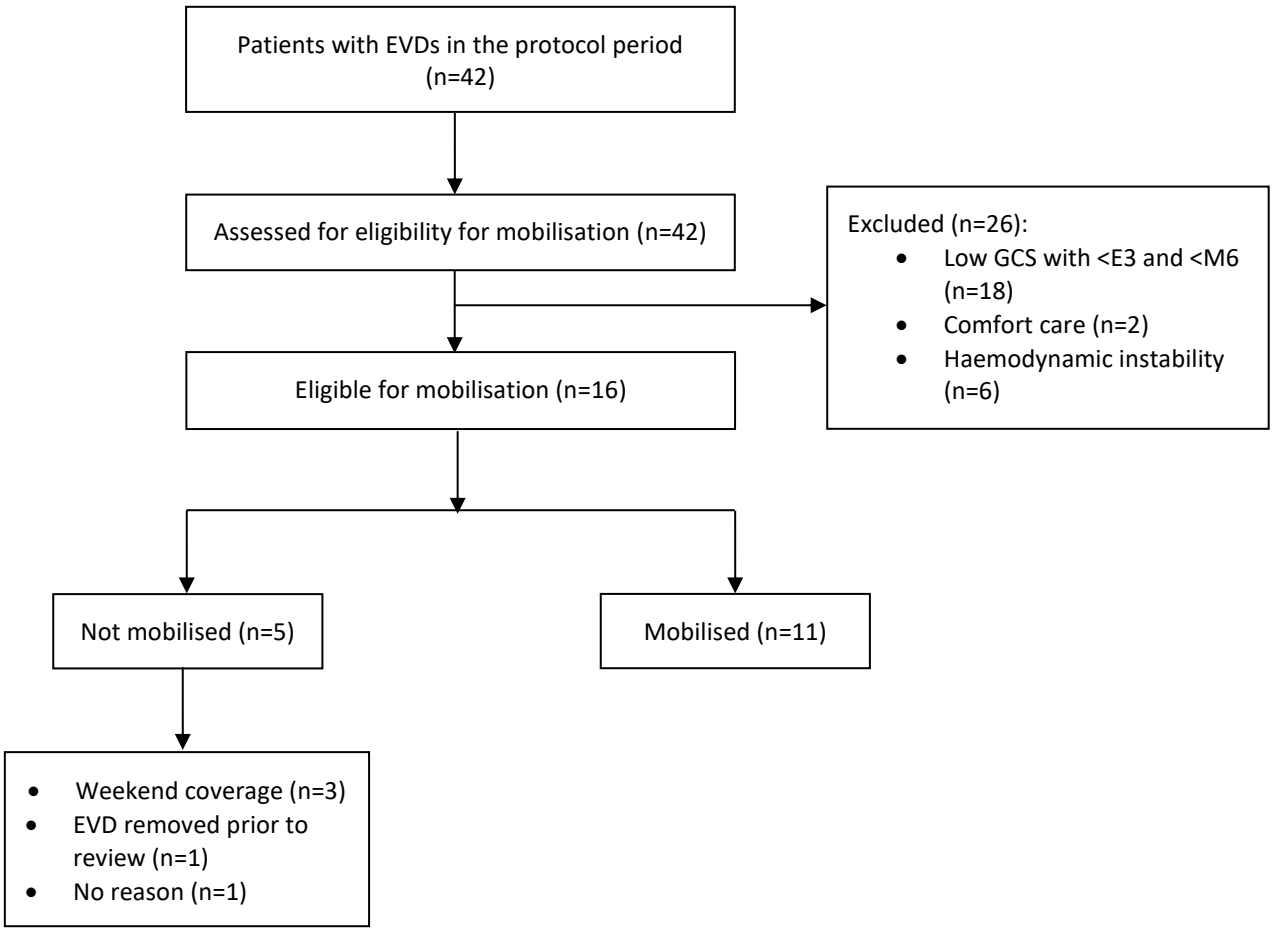

Figure 3. Flow chart for patients' eligibility for mobilisation in the protocol period

Table 3. Eligible patient baseline characteristics

	Patients eligible for mobilisation		
	Pre-protocol (n=25)	Protocol (n=16)	Difference with 95% CI (Protocol – Pre-protocol), p-value
Age (years) [1]	57.0 (46.0-65.5)	61.5 (53.8-65.8)	p=0.467
Gender, n (%) [2]			
Male	17 (68%)	6 (37.5%)	p=0.105
Female	8 (32%)	10 (62.5%)	
Diagnosis, n (%) [2]			
SAH	12 (48%)	9 (56.3%)	p=0.883
ICH	7 (28%)	3 (18.8%)	
IVH	2 (8%)	1 (6.3%)	
Meningitis	1 (4%)	0	
Tumour	2 (8%)	3 (18.8%)	
TBI	1 (4%)	0	
GCS on ED admission [1]	10.0 (5.0-13.5)	14.0 (9.0-15.0)	p=0.023***
Duration of EVD (days) [1]	13.6 (8.5-18.0)	12.0 (6.3-15.0)	p=0.320
On ventilator	0	0	

Definition of abbreviations: CI = confidence interval; ED = emergency department; EVD = external ventricular drain; GCS = Glasgow Coma Scale; ICH = intra-cerebral haemorrhage; IVH = intra-ventricular haemorrhage; SAH = subarachnoid haemorrhage; TBI = traumatic brain injury

*** Level of significance $p<0.05$

[1]Mann-Whitney U test with median (25^{th}-75^{th} percentile)

[2]Fisher's exact Test

Table 4. Safety, feasibility and effectiveness of the early mobilisation protocol

	Pre-protocol (n=75)	Protocol (n=42)	Difference with 95% CI (Protocol – Pre-protocol), p-value
Patients eligible for mobilisation, n (%)	25 (33.3%)	16 (38.1%)	
Eligible patients mobilised, n (%) [1]	1 (4%)	11 (68.8%)	64.8%, 95% CI (35.9%, 82.1%), p<0.0001***
Total number of therapy sessions	1	21	
Highest level of mobility achieved during each session	SOOB 1	SOEOB 10 (47.6%) STS 4 (19.1%) SOOB 0 Marching 5 (23.8%) Ambulation 2 (9.5%)	
Number of adverse events	Information not available	0	
Time from EVD placement to first mobilisation in the hospital (days) [2]	14.0 (9.5-18.0)	3.5 (2.0-7.0)	p<0.0001***
ICU LOS (days) [2]	8.0 (4.0-10.0)	3.5 (2.0-9.0)	p=0.037***
Hospital LOS (days) [2]	38.0 (24.5-54.5)	22.5 (17.8-39.0)	p=0.030***

Definition of abbreviations: CI = confidence interval; EVD = external ventricular drain; ICU = intensive care unit; LOS = length of stay; SOEOB = sitting-on-edge-of-bed; SOOB = sitting-out-of-bed; STS = sit-to-stand

*** Level of significance p<0.05

[1]Fisher's exact test

[2]Mann-Whitney U test with median (25^{th}-75^{th} percentile)

Discussion

This service evaluation demonstrated that the physiotherapy-led early mobilisation protocol in patients with EVDs was safe, feasible and effective within TTSH. The time from EVD placement to first mobilisation, ICU LOS and hospital LOS were significantly reduced in eligible patients. A significantly greater proportion of patients with EVDs were also mobilised in the neurological ICU after protocol implementation, with no recorded adverse events.

In line with Moyer et al (2017) and Young et al (2019), the mobilisation protocol was effective in decreasing the time from EVD placement to first mobilisation, and decreasing ICU and hospital lengths of stay. While LOS is an important outcome, it is difficult to evaluate owing to many contributing factors and is likely not dependent on physiotherapy treatments alone (Gruenberg et al., 2006). Assessment of physical function in patients with EVDs could have provided data more directly associated with the intervention and could be a better outcome measure to examine the effectiveness of early mobilisation in the ICU.

Early mobilisation in patients with EVDs was found to be safe given that no adverse events were recorded. This was in contrast to studies with reported EVD mobilisation protocols in which adverse events, ranging between 0.8% and 5.9% occurred (Moyer et al., 2017, Young et al., 2019). The robust safety profile for mobilisation of patients with EVDs in this study may be due to more cautious eligibility criteria, or differing definitions of adverse events.

A systematic review by Conceição et al (2017), suggested that early mobilisation of critically ill patients could be carried out with reference to specific safety criteria which can be broadly categorised into cardiovascular, respiratory, neurological and orthopaedic-related. In this study, the protocol clearly stated eligibility criteria pertaining to each of the abovementioned physiological systems for initiation of early mobilisation in patients with EVDs. Having such definitive criteria eliminated any ambiguity for determining whether a patient was eligible for mobilisation. Coupled with the mobilisation flow chart that illustrated a step-by-step safety checklist, as well as the collaborative efforts between the nurse and physiotherapist in monitoring the patient's vital signs and symptoms throughout mobilisation, adverse events were avoided.

This study reported an increased in mobilisation rate during the protocol period. Titsworth et al (2012) reported similar finding in the population admitted into the neurological ICU using the Progressive Upright Mobility Protocol Plus. Despite differences in the methods used in quantifying mobilisation rate in both studies, they demonstrated feasibility of introducing a mobilisation protocol within critical care.

This study was not designed as research, but to evaluate a specific service. Patient numbers were small, and data were analysed retrospectively from a single centre with no concurrent control group or randomisation process. Results would not be generalisable to the wider population, although this work provides some practice sharing and learning points. The accuracy of the reported adverse events was dependent on the quality of note-taking at the time of the incident. Eligibility criteria applied retrospectively to the pre-protocol group may have flaws as the medical records

may not have presented a full picture as to whether patients were appropriate for mobilisation.

The clinical implications of having a mobilisation protocol included developing greater confidence amongst physiotherapists and other healthcare professionals in mobilising patients with EVDs. Furthermore, it helped to promote a mobilisation culture within the ICU in this patient population, who traditionally would have been placed on bed rest.

Conclusion

A physiotherapy-led early mobilisation protocol for patients with EVDs enabled safe, feasible and effective mobilisation in one neurological ICU. Although these findings add to the current evidence supporting mobilisation among this patient population, a service evaluation cannot be generalised more widely. Future prospective, controlled research studies are warranted.

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