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Clinical study

Inter-facility transfer of patients with traumatic intracranial hemorrhage and GCS 14–15: The pilot study of a screening protocol by neurosurgeon to avoid unnecessary transfers

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ABSTRACT

We sought to evaluate feasibility and cost-reduction potential of a pilot screening program involving neurosurgeon tele-consultation for inter-facility transfer decisions in TBI patients with GCS 14–15 and abnormal CT head at a community hospital. The authors performed a retrospective comparative analysis of two patient cohorts during the pilot at a large hospital system from 2015 to 2017. In "screened" patients (n = 85), images and examination were reviewed remotely by a neurosurgeon who made recommendations regarding transfer to a level 1 trauma center. In the "unscreened" group (n = 39), all patients were transferred. Baseline patient characteristics, outcomes, and costs were reviewed. Patient demographics were similar between cohorts. Traumatic subarachnoid hemorrhage was more common in screened patients (29.4% vs 12.8%, P = 0.02). The presence of midline shift >5 mm was comparable between groups. Among screened patients, 5 were transferred (5.8%) and one required evacuation of chronic subdural hematoma. In unscreened patients, 7 required evacuation of subdural hematoma. None of the screened patients who were not transferred deteriorated. Screened patients had significantly reduced average total cost compared to unscreened patients ($2,003 vs. $4,482, P = 0.03) despite similar lengths of stay (2.6 vs. 2.7 days, P = 0.85). In non-surgical patients, costs were less in the screened group ($2,025 vs. $2,939), although statistically insignificant (P = 0.38).

In this pilot study, remote review of images and examination by a neurosurgeon was feasible to avoid unnecessary transfer of patients with traumatic intracranial hemorrhage and GCS 14–15. The true potential in cost-reduction will be realized in system-wide large-scale implementation.

1. Introduction

Traumatic brain injury (TBI) is a common reason for transfer to trauma centers for neurosurgical evaluation [1–6]. Results from a recent TRACK-TBI study revealed that less than 50% of patients with so-called "mild" TBI (i.e., Glasgow Coma Score (GCS), 13–15) reported full return to pre-injury levels of day-to-day function at one-year post-injury [7], highlighting the need for further study of long-term functional limitations in this group of patients. Despite these important findings from the TRACK-TBI study, however, urgent neurosurgical intervention in this group of patients is rare [8], and transfer of such patients with high GCS and likely non-operative imaging findings from satellite emergency departments to level 1 trauma centers (i.e., with neurosurgical coverage) may be associated with suboptimal use of higher acuity facility beds and neurosurgical resources, higher costs, and reduced patient satisfaction. The importance of these considerations has been heightened during the COVID-19 pandemic.

Within our large medical center with 40 academic, community, and specialty hospitals, we had no standard protocol for triage of TBI patients, relying predominately on bedside physician decision making. We started a pilot program wherein patients with TBI, GCS score of 14 or 15, and an abnormal computed tomography (CT) head during initial emergency department evaluation at one of our community hospitals triggered a tele-consult to a

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neurosurgeon, who screened the patient for transfer to a level 1 trauma center. We share the feasibility and cost-reduction potential of this pilot program.

2. Materials and methods

2.1. Study population

This is a retrospective review of consecutive inter-hospital transfer requests from January 1, 2015 to December 31, 2017 from the University of Pittsburgh Medical Center (UPMC) Passavant Emergency Department (i.e., a "community" hospital without trauma program or in-house neurosurgery program) to UPMC Presbyterian University Hospital (i.e., an "academic" hospital with level 1 trauma service and neurosurgical resident coverage 24 h each day of the week). Inclusion criteria consisted of patients with GCS 14 or 15 and a confirmed traumatic intracranial hemorrhage by head CT. Patients with TBI and GCS 13 or less, polytrauma, or non-traumatic head bleed (e.g., hypertensive intracerebral hemorrhage, aneurysmal subarachnoid hemorrhage) were excluded.

2.2. Screening process

Prior to this pilot study, patients transferred with identified traumatic intracranial hemorrhage at one of our community hospitals went to a level 1 trauma center with in-house neurosurgical coverage provided by resident physicians. The bedside emergency physicians requested the transfer and shared their concerns but without any structured dialogue, care planning, or image transfer. The senior author (RFS) obtained approval from the source hospital to conduct this pilot study and held a medical staff position at both the originating and receiving sites.

The senior author provided tele-consult coverage nearly every day of the year for three years except on days (i.e., less than 20 days per calendar year) of travel without reliable access to the internet for imaging review. During the study period, the screening neurosurgeon reviewed the patients' images and examination remotely and made a recommendation whether to transfer these "screened" patients to the level 1 trauma center. If not transferred, the patients were admitted to an in-house hospitalist or primary care physician with an established relationship to the patient.

In the first year of the pilot, in the morning following admission the senior neurosurgeon or a certified registered neurosurgical nurse practitioner trained by the neurosurgeon evaluated every patient deemed unnecessary for transfer in person. These patients underwent interval CT head imaging >6 h from initial CT head imaging. By years two and three of the pilot (2016 and 2017), in-person evaluations by the neurosurgeon were deemed to be unnecessary. All patients were instructed to obtain follow-up head CT imaging and to make an appointment with the senior author at one-month post-injury.

We also tracked circumstances when referring emergency medicine physicians at our satellite hospital, who were either unaware of this pilot study or felt strongly that a patient required immediate transfer to the neurosurgical service at a level 1 trauma center, avoided tele-consultation and transferred patients to the neurosurgical service at the UPMC Presbyterian University Hospital. We refer to these patients as "unscreened".

2.3. Data collection

We identified all patients from a centralized administrative database maintained by the medical center. Collected data included age, sex, date of transfer request, method of transportation, and referring diagnosis. Comprehensive review of the inpatient electronic medical record obtained details of patient characteristics including confirmation of diagnosis, use of antiplatelet or anticoagulant medications, mechanism of trauma, and pattern of traumatic head bleed.

Cost data by the finance department at the University of Pittsburgh Medical Center included direct supply, pharmacy, blood transfusions, imaging, laboratory, emergency department, stay at general ward and intensive care unit (ICU), and other miscellaneous costs. We do not report fixed and/or indirect expenses that have an indirect relationship with patient activities; these included finance, human resources, administration, insurance, property, security, and construction. We also excluded physician charges.

2.4. Outcomes measures

The primary outcome was the use of any additional neurosurgical diagnostic tests (e.g. direct subtraction angiography, lumbar puncture), bedside procedures (e.g. external ventricular drain, lumbar drain), or operating room procedures (e.g. craniotomy) in the sentinel hospital care episode.

2.5. Data analysis

We share descriptive statistics including mean values, standard deviation and errors, and 95% confidence intervals. Comparative analyses used include two-tailed Student *t* test, Mann-Whitney U and Chi-square analysis, Fisher's exact test for categorical variables, and analysis of variance (ANOVA) for continuous variables. All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS, IBM, Armonk, New York) with the comparison alpha error set at 0.05.

3. Results

3.1. Transfer requests

During the study period, the screening neurosurgeon received tele-consults on 29, 32, and 24 patients with TBI and GCS 14–15 in 2015, 2016, and 2017, respectively; five unscreened patients (5.8%) were transferred outside this process and without any neurosurgical contact. An additional 16, 10, and 13 unscreened patients, respectively, with TBI and GCS 14–15 in 2015, 2016, and 2017 were transferred after contact with a neurosurgical attending outside the pilot program. These patients are referred to as "unscreened". All unscreened patients were transferred to UPMC Presbyterian University Hospital, a level 1 trauma center. Of all patients transferred, 3 came via air and the remainder via ground transport.

3.2. Patient characteristics

The mean age of patients was higher in the screened (81.2 ± 12.9 years) versus the unscreened (75.1 ± 16.9 years) patients with 90.6% and 16.9% of patients (P = 0.07), respectively, above the age of 65 (Table 1). The most common mechanism of trauma was ground level fall in both groups albeit different between groups: 90.6% in the screened and 76.9% in the unscreened (P = 0.07). Among non-surgical patients, fall was more common as a mechanism of trauma among the screened patients (90.5% vs 71.9%; P = 0.03).

3.3. Imaging findings

Subdural hematoma was more common in the unscreened (74.4%) versus the screened patients (56.5%, P = 0.04 Table 1).

Table 1
Baseline patient characteristics and radiographic findings of all patients.

	Screened (n = 85)	Unscreened (n = 39)	P value
Demographics			
Age (years, SD)	81.2 (12.9)	75.1 (16.9)	0.05
Age ≥ 65 y (%)	77 (90.6)	30 (76.9)	0.07
Sex (Male, %)	33 (38.8)	21 (53.8)	0.12
Aspirin (%)	39 (45.9)	17 (43.4)	0.81
Plavix (%)	8 (9.4)	9 (23.1)	0.07
Coumadin (%)	15 (17.6)	9 (23.1)	0.49
Other anticoagulant (%)	5 (5.9)	1 (2.7)	0.36
Mechanism of injury			
Fall	77 (90.6)	30 (76.9)	0.07
MVA	1 (1.2)	2 (5.1)	0.23
Assault	0 (0.0)	1 (2.6)	0.32
Unknown	7 (8.2)	6 (15.4)	0.34
GCS upon presentation			
GCS 15	80 (94.1)	32 (82.1)	0.07
GCS 14	5 (5.9)	7 (17.9)	0.07
Pattern of bleed			
Subdural	48 (56.5)	29 (74.4)	**0.04***
Subarachnoid	25 (29.4)	5 (12.8)	**0.02***
Intraparenchymal	3 (3.5)	0 (0.0)	0.55
Intraventricular	0 (0.0)	2 (5.1)	0.10
Multicompartmental	2 (2.3)	3 (7.7)	0.24
MLS			
Present (any size)	9 (10.9)	11 (28.2)	**0.03***
≥5 mm	3 (3.5)	4 (10.3)	0.21
Intervention			
Surgery	1 (1.2)	7 (17.9)	**0.001***
No surgery	84 (98.8)	32 (82.1)	**0.01***
LOS (days, SD)	2.6 (3.3)	2.7 (1.9)	0.85

* Denotes statistically significant difference. SD = standard deviation, MVA = motor vehicle accident, MLS = midline shift, GCS = Glasgow Coma Scale, LOS = length of stay.

Conversely, among non-surgical patients, traumatic subarachnoid hemorrhage was more common in the screened patients (35.7% versus 15.6%; P = 0.02, Table 2).

Intraparenchymal hemorrhage was present in 3.5% of screened patients and none of the unscreened. Intraventricular hemorrhage was present in 5.1% of unscreened patients and none of the screened patients. Multicompartmental hemorrhage existed in 2.3% of screened and 7.7% of unscreened patients (P = 0.24). None of the patients in either group had a diagnosis of epidural hematoma. The presence of midline shift > 5 mm was similar between the two groups. Four unscreened patients had midline shift of at least 5 mm, compared to 3 patients in the screened group (10.3% versus 3.5%, P = 0.21).

3.4. Neurosurgical intervention

In the unscreened patients, 7 required surgical intervention (Table 5). Six of these patients had a diagnosis of subdural hematoma (5 of whom had midline shift, range 5–15 mm) and underwent craniotomy for subdural hematoma evacuation. One of the seven patients presented with intraventricular hemorrhage and post-traumatic hydrocephalus requiring lumbar puncture with elevated opening pressure and ultimately required ventriculoperitoneal shunt during the same episode of care.

In the screened patients, 5 were transferred from the satellite hospital to the level 1 trauma center. Of those 5 patients, one patient required a craniotomy for evacuation of subdural hematoma (Table 6.).

None of the screened patients avoiding transfer later deteriorated. Seven patients died at an average of 24.0 months post-injury, for reasons unrelated to head trauma. Four patients were lost to follow-up. The average Glasgow Outcome Scale (GOS) of

Table 2
Baseline patient characteristics and radiographic findings of patients that did not have surgical intervention.

	Screened (n = 83)	Unscreened (n = 32)	P value
Demographics			
Age (years, SD)	81.2 (13.0)	74.8 (18.1)	0.07
Age ≥ 65 y (%)	76 (90.5)	24 (75.0)	0.06
Sex (Male, %)	33 (39.3)	17 (53.1)	0.18
Aspirin (%)	38 (45.2)	14 (43.8)	0.89
Plavix (%)	8 (9.5)	8 (25.0)	0.06
Coumadin (%)	15 (17.9)	8 (25.0)	0.41
Other anticoagulant (%)	5 (6.0)	1 (3.1)	0.48
Mechanism of injury			
Fall	76 (90.5)	23 (71.9)	**0.03***
MVA	1 (1.2)	2 (6.3)	0.18
Assault	0 (0.0)	1 (3.1)	0.28
Unknown	6 (7.1)	6 (18.8)	0.13
Traumatic injury	5 (6.0)	4 (12.5)	0.26
GCS upon presentation			
GCS 15	80 (95.2)	27 (84.4)	0.11
GCS 14	4 (4.8)	5 (15.6)	0.11
Pattern of bleed			
Subdural	47 (56.0)	23 (71.9)	0.10
Subarachnoid	30 (35.7)	5 (15.6)	**0.02***
Intraparenchymal	3 (3.6)	0 (0.0)	0.56
Intraventricular	2 (2.4)	1 (3.1)	1.00
Multicompartmental	2 (2.4)	3 (9.4)	0.13
MLS			
Present (any size)	8 (9.5)	6 (18.8)	0.23
≥5 mm	3 (3.6)	1 (3.1)	1.00
LOS (days, SD)	2.62 (3.38)	2.00 (1.02)	0.13

* Denotes statistically significant difference. SD = standard deviation, MVA = motor vehicle accident, MLS = midline shift, GCS = Glasgow Coma Scale, LOS = length of stay.

Table 3
Financial cost of care for all patients.

	Screened (n = 40)	Unscreened (n = 16)	P value
Direct supply	$3.80 ($19.90)	$333.00 ($544.00)	**0.03***
Pharmacy	$486.00 ($730.00)	$497.00 ($642.00)	0.66
Blood transfusion	$12.90 ($67.00)	$102.00 ($150.00)	**0.04***
Imaging	$150.00 ($205.00)	$104.00 ($125.00)	0.31
Laboratory	$57.80 ($45.30)	$119.10 ($89.40)	**0.02***
Floor (non-ICU Ward)	$611.00 ($335.00)	$625.00 ($790.00)	0.94
ICU	$19.00 ($121.00)	$897.00 ($1581.00)	**0.04***
Emergency room	$170.40 ($34.20)	$178.50 ($67.2)	0.65
Miscellaneous	$466.00 ($483.00)	$1267.00 ($1415.00)	**0.04***
Total	$2003.00 ($2173.00)	$4482.00 ($1013.00)	**0.03***

* Denotes statistically significant difference.

Table 4
Financial cost of care for patients that did not have surgical intervention.

	Screened (n = 39)	Unscreened (n = 12)	P value
Direct supply	$3.80 ($20.10)	$209.00 ($489.00)	0.17
Pharmacy	$499.00 ($2107.00)	$310.00 ($744.00)	0.78
Blood transfusion	$13.20 ($67.80)	$95.00 ($149.00)	0.09
Imaging	$152.00 ($207.00)	$192.00 ($145.00)	0.41
Laboratory	$57.20 ($45.80)	$85.00 ($57.70)	0.14
Floor (non-ICU Ward)	$620.00 ($334.00)	$314.00 ($314.00)	**0.01***
ICU	$20.00 ($123.00)	$715.00 ($1300.00)	0.09
Emergency room	$187.00 ($34.60)	$281.00 ($48.60)	0.11
Miscellaneous	$473.00 ($488.00)	$736.00 ($847.00)	0.32
Total	$2025.00 ($2197.00)	$2939.00 ($3252.00)	0.38

* Denotes statistically significant difference.

Table 5
Characteristics of patients who underwent surgery among both screened and unscreened patients.

Patient	Age (yrs)	Sex	Antithrombotic	Mechanism	GCS	Bleed	MLS	Surgery	LOS (days)
Screened	81	Female	Aspirin	Fall	14	SDH	1 mm	craniotomy	1
Unscreened	85	Male	None	Fall	15	SDH	15 mm	craniotomy	5
Unscreened	66	Male	None	Fall	15	SDH	11 mm	craniotomy	4
Unscreened	86	Female	Aspirin, Plavix	Fall	14	SDH	None	craniotomy	8
Unscreened	85	Male	Aspirin	Fall	15	SDH	5 mm	craniotomy	5
Unscreened	76	Female	None	Fall	15	SDH	10 mm	craniotomy	5
Unscreened	58	Male	Aspirin	Fall	14	SDH	12 mm	craniotomy	5
Unscreened	78	Female	Coumadin	Fall	15	IVH	None	VPS	9

SDH = subdural hematoma, IVH = intraventricular hemorrhage, GCS = Glasgow Coma Scale, IVH = intraventricular hemorrhage, MLS = midline shift, VPS = ventriculoperitoneal shunt, LOS = length of stay.

Table 6
Characteristics of patients who were transferred after screening.

Age (yrs)	Sex	Antithrombotic	Mechanism	GCS	Bleed	MLS	Surgery	LOS (days)
78	Male	None	Fall	15	SDH	None	No	1
81	Female	Aspirin	Fall	14	SDH	1 mm	craniotomy	3
48	Female	None	Fall	15	SDH	None	No	0
61	Male	Aspirin	Unknown	15	tSAH	None	No	0
83	Female	Aspirin, Coumadin	Fall	15	SDH	None	No	1

SDH = subdural hematoma, GCS = Glasgow Coma Scale, SDH = subdural hematoma, tSAH = traumatic subarachnoid hemorrhage, MLS = midline shift, LOS = length of stay.

the remaining screened patients was 4.1 ± 1.2 at the time of last follow-up with average length of follow up of 36.1 months.

3.5. Resource utilization

The mean length of hospitalization in the screened patients was 2.6 ± 3.3 days versus 2.0 ± 1.0 days in the unscreened patients (P = 0.85, Table 1). Mean cost of care in the screened cohort was $2,003 USD and less than the unscreened patients ($4,482 USD, P = 0.03 Table 3). The specific services that differed included direct supply ($3.8 vs $333, P = 0.03), blood transfusions ($12.9 vs $102, P = 0.04), laboratory ($57.8 vs $119.1, P = 0.02), ICU care ($19 vs $897, P = 0.04) and other/miscellaneous ($466 vs $1,267, P = 0.04). Among patients who did not require neurosurgical intervention, the mean length of stay was 2.6 ± 3.4 days in screened patients, similar to that in unscreened patients (2.0 ± 1.0, P = 0.13) (Table 2). Total cost of care was non-significantly lower in the screened group than in the unscreened group ($2,025 versus $2,939, P = 0.38, Table 4).

4. Discussion

In this pilot study, a neurosurgeon provided teleconsultation to emergency medicine physicians at a satellite hospital concerning the need for transfer of patients with traumatic intracranial hemorrhage with GCS 14–15 to a level 1 trauma center, which resulted in the prevention of 94.1% of transfers in the "screened" cohort and a significant reduction in overall associated care costs.

Interfacility transfer of trauma patients has been studied previously. In a 2018 multi-state study concerning the transfer of trauma patients, Medford-Davis et al. reported that over a third of patients with head trauma were discharged from the emergency department upon transfer, without admission at the recipient facility [9]. Of those transferred, the most common reason was lack of access to neurosurgical consultation; the authors suggested telemedicine as a potential solution to this problem. Moya et al. studied the use of a web-based telemedicine platform at the University of New Mexico Health Sciences Center for remote neurosurgical consultations [10]. Using this platform, forty-four percent of transfer requests were avoided [10]. Similar results report on telemedicine consultation for patients with facial, hand, ophthalmic, and burn injuries [11–14]. We think taken together, a structured plan is feasible and potentially helpful in managing those with mild-TBI and avoiding low value transfer.

Safety remains a concern with neurosurgical telemedicine consultation. In a two-year descriptive analysis from the University of Alabama, Kuhn et al. reported that potentially 20% of accepted transfers could have been avoided given that these patients did not require additional neurosurgical diagnostic testing, intervention, or intensive monitoring [5]. Carlson et al. reviewed the transfer of "mild" TBI patients to their respective level I trauma center over a 4-year period [15]. Of the 292 transferred patients, 4 required intervention due to delayed deterioration or progression of radiographic findings on secondary imaging.

While these studies and others [16–17] reviewed potential transfer avoidance in *post hoc* analyses, others attempted to implement systems to actively avoid unnecessary transfers [10,18]. Capron et al. utilized the Brain Injury Guidelines (BIG) criteria; patients in the BIG 1 category (i.e., normal neurologic examination, not on antiplatelet or anticoagulation medications, with small (less than4 mm) intracranial hemorrhage) were deemed safe for avoidance of transfer [19]. In their report, neurosurgeons were not involved in the decision-making process. In our report, only 28.7% of screened patients correlate with the BIG 1 category because 5.9% and 78.8% of our patients avoiding transfer had an abnormal neurological exam (i.e., GCS = 14) and used antiplatelet/anticoagulation medications, respectively. This suggests that involvement of a neurosurgeon in the screening process may be beneficial, although this has been disputed [19–20]. In our series, none of the screened patients avoiding transfer later deteriorated. Seven screened patients ultimately died at an average of 24.2 months post-injury, although the reason for death was unrelated to head trauma. Another four patients were lost to follow-up. The mean Glasgow Outcome Scale (GOS) of the remaining screened patients was 4 ± 1 at the time of last follow-up with mean length of follow up of 36.1 months. These results suggest our proposed screening protocol was safe.

TBI patients with GCS score of 13–15 are often and inappropriately referred to as having sustained, "mild" traumatic brain jury

(TBI) [7]. Nelson and colleagues in the Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) study, reported that 53% of all "mild TBI" patients, and 61% of those with positive CT findings, have functional limitations at one-year post-injury. Despite the clinical sequelae (such as post-traumatic stress disorder, headaches, sleep disturbances) that afflict this patient population long-term, >40% of patients lack appropriate follow-up and supportive services at 3 months post-injury [21]. This observation underscores the opportunity for improvement in continuity of care for this vulnerable patient population. The TRACK-TBI study implies that increased and chronic supportive services may be beneficial for this group of patients. In our series, 87% of patients obtained a repeat CT head within 6 weeks of injury and followed up with the screening neurosurgeon or their primary care physician. This study suggests that the interfacility transfer of these patients can be screened to avoid unnecessary transfers, without detriment to the need for follow up and continued care.

Avoidance of interfacility transfer is associated with potential cost savings [1–8,22]. Arnold et al. retrospectively reviewed the records of TBI patients with GCS 13–15 transferred to a level 1 trauma center in their respective hospital system. Of the 2,120 transferred patients, 689 patients (32.5%) did not require neurosurgical intervention [8]. The authors estimated that more than $700,000 could have been saved with the avoidance of unnecessary transfer. Although prior studies have demonstrated the hypothetical cost-saving potential of interfacility transfer avoidance, our study provides the first report of actual cost savings in this group of TBI patients. Overall, our screened patients had a more than two-fold reduction in total cost of care as compared to the unscreened patients.

The recent pandemic has made judicial transfer of patients to tertiary centers an important factor in avoiding overcrowding of beds in the tertiary centers which care for patients affected by the coronavirus. Tele-consultation will continue to play an increasingly important role in the management of our patients in the future.

5. Limitations

This study has limitations. We know that some emergency physicians at the participating satellite hospital may have avoided neurosurgical tele-consultation and transferred patients. We also did not include patients with a GCS score of 13 in our study to increase the safety of the proposed pilot study. Further, our cost data may not fully represent the total costs of care, especially that of individual physicians involved; nonetheless, the patterns that describe potential opportunity are clear. We used tools as they existed, a strength and a weakness. We did not use a formal telemedicine platform system. Our screening protocol required the neurosurgeon to rely on a physical examination performed by an emergency physician and conveyed through a telephone conversation. One neurosurgeon screened all patients throughout the three-year period of the study. All of these are pragmatic but could later affect the impact of the program when expanded or used elsewhere. A better system-wide application would use collaboration between multiple neurosurgeons and emergency physicians. Finally, this pilot study does not address the services (i.e., within satellite hospitals) used to address the myriad of chronic complaints, which plague many individuals with TBI and GCS scores of 14 or 15.

6. Conclusions

We demonstrate that tele-consultation for transfer of patients with acute traumatic intracranial hemorrhage and GCS 14–15 using a neurosurgeon and the existing emergency medicine department is feasible and may be associated with significant cost savings for the healthcare system. The true cost-reduction and care/outcome impact awaits system-wide large-scale implementation.

7. Disclosures

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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