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ABSTRACT

Background: The model of care for patients with mild-to-moderate head injury and CT-detected lesions that do not require an immediate intervention is a matter of debate. This study compared the effects on outcome of a model based either on observation in a neurosurgical unit (NSU) or in a peripheral hospital (PH), making use of neurosurgical expertise via a teleradiology system.

Patients and methods: The investigation reviewed the data that was prospectively collected in 865 cases with mild-to-moderate head injury and positive CT scan, not needing immediate neurosurgical evacuation. Outcome was determined at 6 months. The predictive value of location of observation on outcome was evaluated by logistic regression, after adjustment for the propensity score to the type of observation (calculated on main entry variables).

Findings: 700 subjects had a mild head injury, 105 had a moderate injury with GCS 13–11 and 60 with Glasgow Coma Scale (GCS) 10–9. Only 152/865 subjects (17.6%) were admitted to a NSU. During observation, neurosurgery was necessary in 117 cases (13.5%), 74/152 (48.7%) NSU-observed patients and 43/713 (6.0%; $p<0.001$) PH-observed cases. The outcome was unfavourable in 18% of the NSU cases versus 10% of the PH cases ($p = 0.143$). After correction for propensity, no significant differences were found between models of observation (NSU vs. PH; odds ratio, 0.92; 95% confidence interval, 0.49 to 1.75).

Interpretation: A model of care based on observation in PH with neurosurgical consult by teleradiology system, repeat CT scanning and transfer time 30–60 min to a NSU is not detrimental for subjects with initial non-neurosurgical lesions after mild-to-moderate head injury.

Subjects with mild-to-moderate head injury (Glasgow Coma Scale (GCS) 15–9) admitted to the Emergency Department (ED) with positive CT scan represent a heterogeneous group of patients with large variability as to injury severity, clinical course, neurological recovery and long-term outcome.[1–4] Patients with mass lesions need immediate neurosurgical intervention and require immediate admission to neurosurgical units (NSUs). A second group needs careful observation in the event that subsequent clinical or radiological deterioration indicates the need for immediate neurosurgical intervention. This group represents a special challenge for emergency physicians, as injury progression is highly variable. In a few cases, progression is extremely rapid and the ultimate outcome might be unfavourable because of delayed diagnosis and transfer to NSUs;[5 6] in other cases, the injury does not progress and the final outcome is usually favourable.

Trauma system coverage is not ubiquitous in Europe and not all trauma centres offer 24-hour neurosurgical cover or bed availability.[7 8] In current practice, most patients with head injury and CT scans that do not indicate the need for immediate neurosurgical intervention are initially admitted to peripheral hospitals (PHs) without NSUs. This practice is, however, a matter of debate. In a recent study, the mortality of subjects with severe head injury was twice as high in patients treated in non-neurosurgical centres in comparison to those admitted immediately to NSUs.[9]

In the general hospital of Forlì, we set up a long-standing observational protocol for all cases admitted to the ED with head injury. We used the large database of subjects with positive CT scan following mild to moderate head injury who did not need immediate neurosurgical intervention to evaluate the effects on outcome of a model based on observation in a NSU versus observation in a PH with neurosurgical expertise via a teleradiology system and a NSU transfer time of 30–60 min (so-called "Hub and Spoke" model).

PATIENTS AND METHODS

Database

All cases attending the ED of our general hospital with mild and moderate head injury are treated according to pre-defined procedures.[10] A number of clinical variables are systematically registered for outcome purposes in each patient according to a specific protocol proposed by the NCWFNS (Neurosurgical Committee of World Federation of Neurosurgical Societies) for subjects with mild head injury (GCS 15–14) and modified for cases with moderate injury (GCS 13–9). The Head Injury Registry consists of the consecutive medical records of all patients attending the ED of Forlì from 1999 for acute head injury within 24 hours from trauma.

Study population, setting and design

We present the analysis of our data to June 2006, when the database included 12 715 consecutively triaged cases living in the area of Forlì, aged ⩾10 years. In 12 242 cases (96.3%), the head injury was classified within 24 hours from trauma as mild (GCS 15–14), in 309 (2.4%) as moderate (GCS 13–9) and in 164 (1.3%) as severe (GCS<9).

The ED of Forlì is part of a general hospital with 450 acute beds, providing general clinical services (except cardiac surgery and neurosurgery). The ED treats about 48 000 subjects per year from a population of 171 000 inhabitants in an area of 1380 km^2; 58% of the population live in an urban environment. The hospital treats more than 20 000 subjects, with 900 admissions to intensive care. The hospital database is directly connected with the General Registry Office of the District.

The subjects selected for the present analysis were all patients with a positive CT scan not requiring an immediate neurosurgical intervention after an acute mild or moderate head injury.

Exclusion criteria were severe hypotension caused by extracranial injuries (systolic blood pressure persistently <90 mm Hg) (8 cases), and penetrating head injury (2 cases). Also excluded were 14 subjects, who needed sedation for intubation before ED admission.

The final outcome was determined 6 months after injury. First, a systematic search of all patients with intracranial lesions was carried out by checking the death certificates and the medical databases of our local health district. Following this, a member of the ED staff contacted all the patients who survived by means of a structured telephone interview, to determine the presence of disability.

The protocol of the present report was carried out according to the Helsinki Declaration and approved by the senior staff Committee of the Azienda Unità Sanitaria Locale of Forlì, a board regulating non-interventional studies and equivalent to an Institutional Review Board.

Model of care

On admission to ED, general physical and neurological examinations are performed and routine laboratory tests taken. A cranial CT scan is routinely performed within 2 hours of injury. The non-contrast scan protocol involves 5 mm cuts from the foramen magnum to the vertex, using third-generation equipment. On completion of the CT scan, a teleradiology consultation takes place between the emergency physician and the neurosurgeon. The NSU of Cesena is the referral centre of a network of seven integrated hospitals (''Hub and Spoke'' model).

Transfer to NSU was dictated by clinical judgment and lesion severity and type, as having of a higher probability of evolution, to avoid any delay occuring if neurosurgical intervention should become mandatory. Except for patients requiring neurosurgical intervention, care is identical at both institutions.

According to our protocol,[11] all patients with lesions of Marshall category III and IV (basal cistern compression and/or midline shift) would require immediate transfer to a NSU,[12 13] whereas the location of observation for patients belonging to Marshall category II (no mass lesion, intracranial lesions of a volume less than 25 cc, no aspects of basal cistern compression and/or midline shift) are discussed on a case-by-case basis. However, several violations of the protocol occurred, because of constraints in NSU resources and old age. Overall, only 69/196 cases (35.5%) with lesions belonging to Marshall category III, and 21/51 (41.2%) of subjects with category IV were admitted for observation to a NSU. Subjects with lesions in Marshall category II were admitted to a NSU in only 62 of 618 cases (10%).

The time interval between the trauma and the admission CT scan was recorded for each patient. Also recorded were any subsequent control CT scans, carried out according to clinical and radiological results, within 72 hours from the original event. The observation schedule was carried out according to a pre-defined protocol shared by EDs and NSUs all over the area, and consisted of follow-up GCS (after 60 and 120 minutes and then every 2 hours), and additional CT scans after 6, 12 or 24 hours from admission, according to the suggestions of the neurosurgeon, or at any time, should neurological deterioration occur.

For the purpose of the present study, all CT scans were reviewed retrospectively by two investigators (AF and AV), to confirm the initial diagnosis, and were classified according to the criteria of Marshall *et al*,[12] modified according to the revision of the European Brain Injury Consortium (EBIC).[13]

Definition of variables

Ten variables were selected as the criteria jointly considered by the emergency physician and the neurosurgeon to determine the need for immediate transfer to a NSU. They were based on the clinical status (age, coagulation status, Charlson Co-morbidity Index, and Injury Severity Score), the neurological status (GCS) and the CT scan results (Marshall category[12] and the type of injury – presence of traumatic subarachnoid haemorrhage (t-SAH), subdural haematoma (SDH), epidural haematoma (EDH), intracerebral haemorrhage (ICH) or basal skull fracture (BSF)).[2]

The Charlson Score for co-morbidities was calculated for each subject on the basis of history of diabetes, hypertension, coronary artery, respiratory, neurological and gastrointestinal diseases, as well as permanent disability.[14] In our protocol, the presence of cardiovascular disease and permanent disability were given 2 points.

Injuries were coded by experienced medical personnel according to the Abbreviated Injury Scale[15] for any body region (Head-Neck, Face, Chest, Abdomen, Extremities, External). The Injury Severity Score[15] was calculated as the score derived from the three most severe injuries of each body region. Admission CT data were available in all patients.

Patients' coagulation status (prothrombin time, partial thromboplastin time and platelet count) was carried out by protocol in all cases. Normal values of the International Normalized Ratio (INR) for our laboratory are <1.4.

The need for neurosurgical intervention because of clinical and/or radiological deterioration during the observation period was only considered in the first 7 days after diagnosis, in order to exclude delayed complication of the injury (chronic subdural haematomas, hygromas or hydrocephalus).[2]

Outcome measures

The main outcome measure was the Glasgow Outcome Scale (GOS)[16] at 6 months. For ease of analysis and reporting, the five-point GOS score was categorised as either favourable (moderate disability or good recovery) or unfavourable (dead, vegetative or severe disability). The follow-up GOS was rated by an expert physician unaware of the study protocol, on the basis of the response to a structured telephone call.[2]

Analyses

Mean value, standard deviation, median and interquartile range (IQR), and frequencies, were used to describe data distribution. Multivariate logistic regression analysis was used to identify location of care as related to outcome.

To adjust data for the potential bias of higher severity in subjects immediately transferred for observation to a NSU versus those observed in a PH, we calculated the propensity score (PS) by a separate logistic regression analysis. PS is the conditional probability for a patient chosen randomly to be directly observed in a NSU given the list of covariates jointly considered by the emergency physician and the neurosurgeon as indicative of potential disease progression. The score, ranging from 0 (PH observation) to 1 (NSU observation), is found by predicting treatment group membership. As it is recommended that covariates be introduced generously into such a PS model, we included a large number (n = 10) of covariates independently of significance thresholds or other selection criteria.[17–20] The full list of covariates in the PS model can be found in table 1. The multivariate logistic regression model of main variables for admission for NSU observation to a versus a PH is reported in table 2.

We checked the validity of our model testing the relationship between the estimated propensity for a NSU (coded for terziles) and unfavourable outcome.[21]

Finally, to further confirm our results, we also matched all subjects admitted to a NSU with the subject observed in a PH with the closest PS.

Statistical analyses were performed running the SPSS/PC+ statistical package 13.0 on a personal computer.[22] Two-tailed p values less than 0.05 were considered statistically significant.

RESULTS

Database

The median age of the 865 patients with intracranial lesions after CT scan and GCS 15–9 was 62 years (IQR, 34 to 78), with 282 (32.6%) patients under 40 years and 285 subjects (33.0%) >75 years. Subjects admitted to a NSU were significantly younger than subjects observed in a PH (median 44 vs. 59 years, respectively; $p<0.001$).

The most common co-morbidities were coronary artery disease (203 cases, 23.5%) and neurological diseases (144 cases, 16.6%) without differences in relation to disposition. A total of 65 cases (7.5%) were on warfarin treatment without differences in relation to NSU admission (table 1). The vast majority of subjects had a mild head injury and GCS 14–15 (700 cases, 80.9%), 105 cases had a moderate injury with GCS 13–11 (12.1%), and only 60 cases had a moderate injury with GCS 10–9 (6.9%).

Intracranial lesions

After positive CT scan and neurosurgical consultation by teleradiology system, only 152/865 subjects (17.6%) were transferred to a NSU for observation. In the initial CT scan, a single lesion was demonstrated in 564 cases (65.2% of positive CT scan), whereas 301 cases (34.8%) had two or more lesions. The most common intracranial lesions were ICH (582 cases; 67.3%), acute SDH (328; 37.9%), t-SAH (205; 23.7%) and EDH (39; 4.5%). In 822 cases (95.0%), an additional CT scan was repeated within 24 hours (at 6, 12 or 24 hours according to clinical status).

Surgical intervention during the observation period

During observation, 117 cases (13.5%) required neurosurgical intervention for clinical/radiological deterioration. In particular, neurosurgery became mandatory in 74/152 cases observed in a NSU (48.7%) and only in 43/713 (6.0%; $p<0.001$) observed in a PH, the difference being largely explained by differences in disease severity. In 24 cases, the intervention was required for EDH, in 63 cases for SDH and in 30 for ICH. A total of 90 cases (9.3% of subjects observed in both units) required an additional surgical intervention for orthopedics, thoracic or abdominal lesions, which was carried out according to clinical status either in Forlì or in Cesena.

Unfavourable outcome

A complete follow-up was obtained in almost all cases: 847/865 cases (97.9%). Of the remaining cases, 3 patients died because of complications unrelated to head trauma (one case of severe major orthopaedic injuries; one myocardial infarction, and one stroke). Five cases were lost to follow-up, and GOS was unreliable in 10 cases, due to either a previous disability (5 cases) or a trauma-related disability unrelated to head injury (5 cases).

The outcome was unfavourable in 90 cases (10.5%) (fig 1). Twenty-four patients died (GOS 1, 3.0%): 12 during the hospitalisation period, 12 during the 6-month follow-up. Five patients were judged to be in a permanent vegetative state (GOS 2, 0.7% of total) and 61 were severely disabled (GOS 3, 7.1%). The majority of cases (775 cases, 89.6%) had a favourable outcome, with moderate disability being present in 93 cases (GOS 4, 12.0%).

In general, the unfavourable outcome was slightly more common in subjects admitted to a NSU (14/152, 17.9%) than in

Table 1 Clinical characteristics of subjects with intracranial injury (number of cases and %, or median and interquartile range) according to observation either in a neurosurgical unit or in a peripheral hospital

	Neurosurgical unit (n = 152)	Peripheral hospital (n = 713)
Males	120 (78.9%)	450 (63.3%)
Age (median: IQR)	44 (30–66)	59 (35–79)
Charlson Score (median: IQR)	1 (0–2)	0 (0–1)
INR >2.0	16 (10.5%)	49 (6.9%)
Glasgow Coma Scale		
15–14	109 (71.7%)	591 (82.9%)
13–11	36 (23.7%)	85 (11.0%)
10–9	23 (15.1%)	37 (5.2%)
Injury Severity Score (median: IQR)	17 (17–19)	16 (11–18)
Marshall Category		
Category 2	62 (40.84%)	557 (78.1%)
Category 3	69 (45.4%)	127 (17.8%)
Category 4	21 (13.8%)	30 (4.2%)
Basal skull fracture	24 (15.8%)	60 (8.4%)
Epidural haemorrhage	26 (17.1%)	13 (1.8%)
Subdural haematoma	100 (65.8%)	258 (36.2%)
Intracerebral haematoma/contusion	64 (42.1%)	475 (66.6%)

INR, injury severity score.

Table 2 Multivariate logistic regression model of main variables considered for admission for observation to a neurosurgical unit versus a peripheral hospital in patients with intracranial injury after mild-to-moderate head injury

Covariates	Odds Ratio (95% CI)	p Value
Age	0.98 (0.97–0.99)	<0.001
Charlson Score	0.93 (0.80–1.09)	0.375
INR	1.47 (0.95–2.28)	0.081
Injury Severity Score	0.95 (0.91–0.99)	0.022
GCS	0.88 (0.77–1.01)	0.078
BSF	1.04 (0.55–1.97)	0.909
Marshall Category	3.07 (2.19–4.29)	<0.001
SDH	5.32 (2.86–9.87)	<0.001
EDH	21.89 (8.12–59.04)	<0.001
ICH	0.93 (0.54–1.60)	0.796

Age, Charlson score, INR, Marshall category and GCS were considered as continuous variables; BSF, SDH, EDH and ICH were considered as dichotomized variables.
BSF, basal skull fracture; EDH, epidural haemorrhage; GCS, Glasgow Coma Scale; ICH, intracerebral haematoma/contusion; INR, Injury Severity Score; SDH, subdural haematoma.

subjects observed in a PH (67/713, 10.0%; p = 0.143), the difference being largely explained by higher disease severity.

In subjects who developed an evacuated mass lesion (Marshall category 5), the outcome was unfavourable in 7/74 cases (9.5%) observed in a NSU and in 2/43 cases (4.6%) observed in a PH (not different). In the remaining subjects, the outcome was unfavourable in 14 cases (17.9%) observed in a NSU and in 67 (10.0%) observed in a PH (not significantly different). Among these cases, a non-evacuated mass lesion (Marshall category 6) occurred in 2/78 subjects (2.6%) observed in a NSU and in 11/670 (1.6%) observed in a PH (fig 1). In this last group, death occurred in 21/670 subjects (3.1%), but death was not related to complications associated with head injury in 8 subjects. Overall, head-injury-associated death and unfavourable outcome were not systematically higher in subjects observed in a PH (ANOVA; p = 0.511).

Outcome prediction by propensity score

NSU observation was associated with a less favourable outcome at 6 months (OR, 1.50; 95% CI, 0.89 to 2.52; p = 0.131), in relation to a more severe disease in NSU cases, but this was no longer the case when the outcome of NSU disposition was tested after correction for PS (OR 0.92; 95%CI, 0.49 to 1.75; p = 0.810) (table 3). In particular, no differences were observed in the three strata of terziles of PS, although the absence of events in the lower tertile prevented a correct calculation of odds (table 3). The correlation was confirmed in a separate analysis by paired subjects selected on the basis of similar values

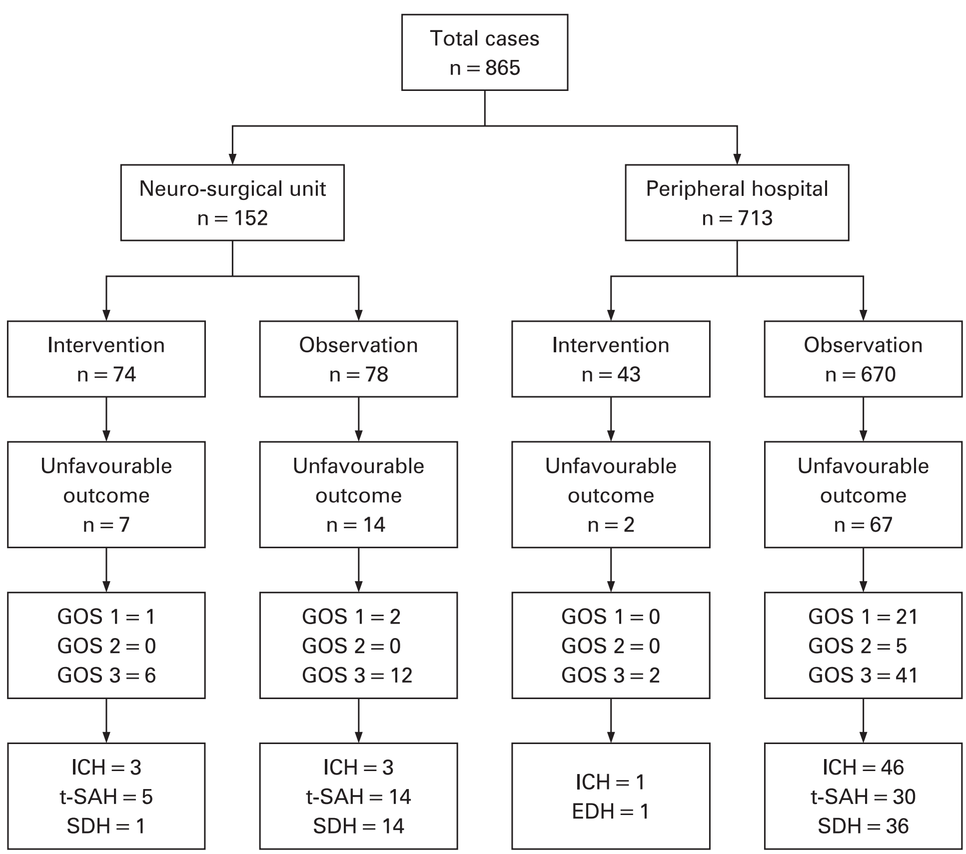

Figure 1 Clinical course of subjects with positive CT scan following mild-to-moderate head injury that unequivocally did not require an immediate neurosurgical intervention in relation to location of observation either in a neurosurgical unit (NSU) or in a peripheral hospital (PH) with neurosurgical expertise only via a teleradiology system and transfer-time of 30–60 min (so-called ''Hub and Spoke'' model). EDH, epidural haemorrhage; GOS, Glasgow Outcome Scale; ICH, intracerebral haematoma/contusion; SDH, subdural haematoma; t-SAH, traumatic subarachnoid haemorrhage.

Table 3 Propensity score analysis: comparison of unfavourable outcome predicted by selected covariates across strata (terziles) of the propensity score to be admitted for observation to a neurosurgical unit (NSU) versus a peripheral hospital (PH)

Strata	Propensity score	NSU disposition	PH disposition	Odds ratio (95% CI)	p Value
1	0.0124–0.0694	8	280	0.00 (0.00)	0.999
2	0.0694–0.1529	31	258	2.28 (0.67 to 7.74)	0.185
3	0.1544–0.9949	113	175	0.76 (0.37 to 1.58)	0.470
All cases		152	713	0.92 (0.49 to 1.75)	0.810

of the propensity score, where NSU admission did not change outcome (OR, 0.69; 95%CI, 0.32 to 1.14, p = 0.343).

Data did not change significantly when subjects with mild or moderate head injury were analysed separately (not reported in details). Similarly, when the analysis of unfavourable outcomes was extended to include subjects with moderate disability (GOS 4), no differences were observed in relation to modes of care.

Discussion

The present study confirms that a model of care based on observation in a general hospital with telemedicine facilities ("Hub and Spoke" model) does not put patients with mild-to-moderate head injury and positive CT scan at higher risk. These data may be used by healthcare providers to plan a cost-effective use of resources in this group of critical patients, prone to sudden clinical and/or radiological deterioration, where urgent neurosurgical intervention may be needed.

The prognosis of these patients is extremely variable, and favourable in more than 80% of cases. Different figures reported in the literature are probably due to peculiar characteristics in specific settings.[16] The most relevant issue remains a careful initial assessment, continuous observation and easy access to neurosurgery in the event of progression.

In most European countries, the decisions about direct admission of patients to hospitals with a NSU are often based on early initial CT scan findings and the demonstration of surgical lesions.[23] Admissions are also driven by the availability of the necessary facilities for neurosurgical intensive care,[23] and reluctance to centralise all subjects with intracranial injury in neurosurgical centres is due to limited bed availability in specialist units and cost constraints. In some European areas, the American Trauma Life Support statement indicating that all patients with a GCS below 14 should be centralised in hospitals with neurosurgical facilities would overwhelm the neurosurgical resources. In patients with severe head injury, the odds of death of patients admitted to a non-neurosurgical centre was reported to be increased two-fold when compared to that of subjects treated in a neurosurgical centre[9] (also after case-mix adjustment with other prognostic factors such as age, Revised Trauma Score and ISS by the PS). Data of subjects with moderate head injury (also the most severe forms with GCS 9–10) are less convincing. In the European Union, head injury guidelines suggest immediate transfer to specialised centres,[24] but the question is open and most cases are usually managed outside NSUs.[9]

We addressed this issue by means of a retrospective observational study on a prospectively collected database and the use of the PS. The inclusion of the PS in our analyses is a method to keep selection bias to a minimum in this type of study,[19] and to increase external validity.[20] The majority of the studies quoted above were derived from neurosurgical settings, in which a neurosurgical triage does not generate data that allows external validity testing for individual cases admitted to EDs in hospitals without a NSU. The PS methodology is an attempt to reconstruct *a posteriori* a situation similar to a random assignment with respect to outcome, given the observed covariates, in a condition where modes of care cannot be easily standardised. Of course, the PS makes an effective balance of covariates used to construct the score but, at variance of randomisation, it cannot be expected to remove hidden biases. Accordingly, the results should be only considered as exploratory findings, although *ad hoc* randomised controlled studies in this area seem difficult to carry out.

We observed CT evolution and evacuated mass lesion in more than 13% of cases, but only a minority of patients developed a non-evacuated mass lesion with unfavourable outcome (8 deaths, 1 vegetative state and 4 severe disability), but without differences in relation to mode of care. Eight of these subjects were observed in a PH, but most of them were characterised by polypharmacology and advanced age (median 84 years), largely accounting for outcome.

The growing elderly population and the expanding indication for anticoagulant treatment are expected to produce more traumatic intracranial injuries, challenging the emergency physicians more and more. In our series, 65 cases (7.5%) were treated with anticoagulants with an INR above 2.0 in a population in which 203 cases (23.5%) cases had cardiovascular disease. In a previous report, we showed that anticoagulation increases, by more than 4 times, the risk of unfavourable outcome, independently of other variables,[2] but this issue is not considered in several analyses.[9] There is a need for studies assessing the clinical importance of rapid reversal of anticoagulation.

In addition, age is an important matter of discussion. In our series, 412 (47.6%) were >65 years old, whereas subjects aged over 65 years were excluded from the analyses in the study of Patel *et al*.[9] In addition, in the latter study, the median age was 33 years in subjects treated in a NSU and 31 in those admitted to non-neurosurgical centres,[9] completely different figures from those of our series reflecting the "real world" of head injury cases observed in EDs, where the median ages were 44 and 59 years, respectively, in keeping with previous reports.[11 25] Our analysis identifies younger age as a significant, independent predictor of propensity to admission to a NSU, but age has never been considered by guidelines as a criterion for admission to neurosurgery and/or for refusing surgery. Although the severity of lesion may be largely independent of age, the probability of an unfavourable outcome is expected to increase with ageing, with 34/117 subjects over 65 years old being operated on for progressive deterioration. In this group, 4 cases had been observed in a NSU (1 death and 3 GOS-3), 2 in a PH (all GOS-3).

This study was not designed to test the hypothesis that subjects with different lesions might be treated more successfully by different modes of care, but only to test the possible disadvantage of peripheral observation. Patients with mild-to-moderate head injury represent a heterogeneous group, and disease progression is largely unpredictable. In our setting, the system of teleconferencing and shared decision by emergency physicians and neurosurgeons led to a limited group of subjects needing late transfer and surgery, and the final prognosis was much more dependent on clinical variables than on location of care. As an example, SDH was the initial diagnosis more commonly associated with adverse outcome (55/358, 15.3%), but this occurred in 19/100 (19%) cases observed in a NSU as well as in 36/258 (14%) observed in a PH. More importantly, cases with evolving lesions potentially treatable with success by neurosurgery were not missed when observed in a PH. The fate of the two cases with EDH observed in a PH did not depend on location of care. A 31-year-old man with an evolving lesion at 6 hours was transferred to a NSU and operated on with good recovery. The second patient had an unfavourable outcome (severe disability) after intervention. This was an 88-year-old man, in whom CT evolution occurred 6 hours after admission to a PH without any appreciable signs of clinical deterioration. Our policy does not reduce the essential contribution of the neurosurgeon in the assessment and decision about each individual patient. However, the contribution can be obtained by means of telemedicine and a protocol for repeat of CT scanning, avoiding transportation to NSU of cases who do not necessarily need or cannot get advantage from neurosurgery. Collaboration between neurosurgeons and emergency physicians is probably the best and most cost-effective way to care for these critical patients.

A few limitations must be acknowledged. The main limitation refers to collecting data from a single hospital, with an extensively developed integration with referring units outside. In this way, it is difficult to generalise our findings to the general European situation.

In addition, the clinical characteristics of subjects with mild-to-moderate head injury were obtained from variables registered on a prospective database, but all analyses were retrospectively performed, potentially creating a bias to results. Finally, the calculation of GCS after ED stabilisation may be a problem. In cases with evolving lesions, GCS at admission might be underestimated and sedative drugs might hinder GCS calculation, particularly in subjects with most severe head injury.

A final problem stems from the calculation of the GOS at follow-up. It was derived on the basis of a structured telephone interview. Questionnaires are known to underestimate rather than overestimate the results,[16] but telephone-reported disability may be a problem.[26]

Our data show that subjects with a positive CT scan after mild-to-moderate head injury and initial non-neurosurgical lesions are not exposed to extra risks when disposed for observation in a PH with neurosurgical consultation on a telemedicine system and 30–60 min NSU transfer-time in comparison to immediate NSU disposition. In case of neurosurgical need, the transfer time may be used to prepare the operating theatre, and the time-to-operation is not different from that of internal transfer. Whenever the connection between PHs and NSUs is based on well-defined protocols and telemedicine systems, the management of selected groups of mild-to-moderate head-injured patients with positive CT scans outside NSUs is feasible. The outcome of these patients remains dependent on a group of selected variables associated with the severity of trauma and head lesion, not from disposition.

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