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The European Brain Injury Consortium Survey of Head Injuries

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Summary

To provide a picture of contemporary practice, a survey was carried out of severely and moderately head injured patients admitted to 67 'neuro' centres in 12 European countries. 1,005 adult head injuries were recruited over a three month period. Sixty items of information on demography, clinical features, investigations, management and early complications were captured on a simple, two-page questionnaire and, information on outcome at six months on a third page.

The median age of the subjects was 38 years, 74% were male and 51% injured in road traffic accidents; 57% of patients were transferred to the 'neuro' centre from another hospital. Assessment of clinical responsiveness was limited by the use of sedation and intubation and information from four early time points (pre-hospital, arrival at the Accident and Emergency department, post-resuscitation, and arrival at the 'neuro' unit) was combined to stratify the subjects as severe (58%), moderate (17%) or intermediate (19%). In 48% of patients classified the CT scan showed features of a 'mass lesion' and in 40% showed a subarachnoid haemorrhage. Fifty-five centres provided the data on outcome for 94% of the cases recruited in these centres six months after injury. 31% died, 3% were vegetative, 16% severely disabled, 20% moderately disabled and 31% had made a good recovery. Comparison of the data from different parts of Europe showed differences in the frequency of secondary transfer, cause of injury, occurrence of major extracranial injury, CT scan findings, intracranial operation, clinical severity of injury and utilisation of the components of intensive care and the occurrence of a favourable outcome, although the latter difference was not statistically significant when variations in the initial severity of injury were taken into account.

The findings in the present survey are compared with newly analysed information for three previous large series: the International Data Bank involving the UK, the Netherlands and the USA, the North American Traumatic Coma Data Bank, and data from four centres in the UK. The comparisons showed substantial similarities and also differences that may reflect variations in policy for admission of the head injury to 'neuro' units, and evolution in methods of assessment, investigation and management. The effects of these differences on outcome requires further, rigorous prospective study.

Keywords: Head injury; European survey; management; outcome.

Introduction

The European Brain Injury Consortium (EBIC) is a network of European units, experienced in the care of head injured patients, and was formally constituted in 1995 [38]. The Consortium promotes international, multicentre, interdisciplinary research aimed at improving the outcome of patients who have suffered a head injury or other kind of acute brain damage. During the formal establishment of EBIC, it was de-

cided to conduct a survey of head injured patients in the interested centres.

The survey had three purposes. First, the exercise would test if it was possible to collect comprehensive, credible data through an organisation with strong commitment but only modest resources. Second, the results would be of considerable intrinsic interest and importance: existing comprehensive databases on severe head injury are over a decade old [9, 15, 23, 28] – and more recent reports concern only selected populations entered into clinical trials. The survey therefore would provide a unique picture of contemporary practice in different parts of Europe and how the findings related to previous data. Third, the results would be invaluable for conducting 'what if?' evaluations of potential inclusion/exclusion criteria for formal clinical studies and trials, for example, the proportion of severe head injuries who are admitted to a neurosurgical unit within different times of injury, or with different clinical states and how they are currently managed, and how these factors influence the outcome expected with 'conventional' treatment.

In this paper we describe the features of the 1005 adult patients, considered to have a severe or moderate head injury, reported to the European Core Data Bank, and compare the findings in different groups of subjects and in different parts of Europe. The results of the present series are compared to previous reports of multicentre series collected prospectively in routine clinical practice. Problems, identified in the current series in defining clinical severity of the injury, are addressed in relation to previous experience. The findings in the more selected populations customarily recruited to trials of pharmacological agents are considered in a separate paper [20].

Methods

A two page questionnaire was designed to capture 60 items of information on demography, clinical features, investigations, management, complications and early outcome. The first page covered the first day following the injury, and included age; sex; cause of injury; mode of admission to the neurosurgical hospital (direct or transfer); timing of injury, admission to first hospital and admission to the neurosurgical hospital; details of any extracranial injuries; clinical evidence of severity of injury was assessed by the Glasgow Coma Scale (GCS) [39] and pupil response to light. Data were recorded at four stages: 1. pre-hospital (ie the first reliable observation made by a 'paramedic' or medical staff); 2. arrival at the Accident and Emergency Department of the hospital where the patient was first taken; 3. post resuscitation (ie the state after initial resuscitation); 4. neuro unit (ie the point at which the patient comes under specialist, usually neurosurgical, care but also neurointensive and neurological). Features such as early complications (hypoxia, hypotension or hypothermia); the results of an admission CT scan; details of any intracranial operation within the first 24 hours and of any emergency extracranial operations were also covered. The second page covered the hospital care up to discharge from the neurosurgical hospital and included details of management and monitoring (intracranial pressure monitoring, ventilation, jugular SVO_2 monitoring, invasive blood pressure monitoring); the results of a final CT scan; details of any intracranial complications which required treatment (delayed haematoma, raised ICP, meningitis/ventriculitis, seizures); details of any life threatening systemic complications (respiratory, cardiovascular, metabolic, infection); timing and mode of discharge; and cause of death where applicable.

Patient Inclusion

The data collection exercise ran from 1st of February 1995 to 30th of April 1995. All centres that had, at that time, expressed interest in EBIC were invited to participate and were asked to return details of all moderate or severe adult (>16 years) head injuries admitted to their care within 24 hours of injury. Patients were to be included if their Glasgow Coma Score [40] was 12 or less at any of the four stages described above, this corresponds to previous definitions of severe (GCS 3 to 8 [9, 23]) and moderate (GCS 9–12 [34]) head injuries.

Data relating to the first 24 hours following injury were to be returned to the EBIC Co-ordination Centre by mail or fax within one week of admission, and the discharge forms were sent in batches at the end of each month. After the collection of the initial data was completed, centres were contacted to ask for details of each patient's outcome six months following their injury. For this, a third, one page questionnaire was designed which gathered information on whether the patient was alive at six months and, if so, the status on the Glasgow Outcome Scale [14]. The GOS is generally accepted as a valid measure of outcome after head injury, with adequate observer reliability [21]. General definitions on outcome categories were provided to centres, but assignment of subjects was not based on a structured interview as has recently been proposed by Wilson *et al.* [44]. An individual form was prepared for each patient in the survey, and these forms were sent to centres for completion.

The entire survey was designed to be conducted on a very limited budget. In particular, there were no resources for additional research assistants, or for site visits to check data against source records. The monitoring was limited to checking the forms as they were received at the EBIC Co-ordinating Centre, and any inconsistencies in the data were queried with the relevant centres. On completion of the data collection, a report was generated which was tailored for each individual centre. This reported detailed results for that centre, together with results for the relevant country and for the entire series, and gave an opportunity for the centres themselves to raise queries with the data.

Results

Response Rate

Core Data forms were sent to 104 centres, and of these 67 (64%) in twelve countries returned data on a total of 1005 adult head injuries. Forty seven (5%) of the cases were injured just outside the three month window set for the survey but are included and this report gives results for all 1005 cases. Table 1 gives the

Table 1. *Summary of Cases Reported*

Country	Number of centres	Number of cases
Germany	19	241
United Kingdom	15	219
Italy	10	184
France	4	95
Spain	3	90
The Netherlands	4	58
Sweden	4	46
Finland	1	19
Switzerland	2	18
Denmark	2	15
Yugoslavia	1	11
Belgium	2	9
Total	67	1005

numbers of centres and the number of cases per country, with the countries ordered by number of cases.

Demographics

Differences in patient demographics, treatments, complications and outcomes between various regions were analyzed with the chi-squared test.

The patterns of age (mean 42, median 38 years), sex (74% male) and cause of injury (51% some type of road traffic accident) are shown in Table 2.

Referral to "Neuro" Unit

Only 43% of patients were admitted directly to a hospital with neurosurgical facilities, the remaining 57% were transferred secondarily from another hospital. Patients admitted directly to the hospital containing the neurotrauma unit took rather longer to reach hospital (median 45 minutes) compared to those admitted to another hospital for assessment before transfer (median 35 minutes). On the other hand, direct admission to a hospital with a neurotrauma unit was associated with a shorter time from injury to the patient coming under specialist care (median 1 hour) in contrast with a median of four hours for patients transferred from another hospital. Such direct admission was the rule in Spain and the Benelux countries, whereas secondary transfer was the rule in the UK, France and Scandinavia, with Italy and Germany occupying intermediate positions.

Clinical Assessment

Assessment of the components of the Glasgow Coma Scale was limited by widespread use of sedation and intubation. Table 3 summarises the proportion of cases where GCS was recorded at different time points (including situations where the GCS was recorded as 'untestable'), and those where GCS could be assessed.

Table 2. *Features of Patients Reported to the European Brain Injury Consortium Core Data Survey*

Period	1995 February – April	
Criteria		
age	adult (>16 years)	
GCS	severe (≤8) or moderate (9–12) at pre Hospital, A&E, post-resuscitation or admission to NSU	
other	admitted to NSU within 24 hours of injury	
Total sample size	1005	
Direct admissions	422/989 (43%)	
age		
mean	42	
SD	21	
median	38	
range	2 to 92 (23 aged ≤14)	
interquartile range	24 to 59	
Male	738/1000 (74%)	
Type of injury	number	percent
motor vehicle occupant	295	(30%)
pedestrian	126	(13%)
RTA other (or unknown)	87	(9%)
work	63	(6%)
assault	53	(5%)
domestic	122	(12%)
sport	30	(3%)
fall under influence of alcohol	121	(12%)
other	99	(10%)
	996	
Major extracranial injury	354/982	(36%)
Initial CT classification		
diffuse I	121	(12%)
diffuse II	273	(28%)
diffuse III	101	(10%)
diffuse IV	21	(2%)
mass	467	(48%)
	983	
Subarachnoid haemorrhage on CT	385/953	(40%)
Intracranial operation (within first 24 hours)		
no	569	(57%)
burr hole for ICP alone	85	(8%)
other	346	(35%)
	1000	
Ventilated	736/948	(78%)
ICP monitored	346/945	(37%)
Jugular SVO_2 monitored	173/939	(18%)
Arterial pressure monitored	631/933	(68%)

Table 3. *Availability of Glasgow Coma Scale at Different Stages in the Early Triage and Management of Head Injured Patients*

	Pre-hospital	A&E department	'Post-resuscitation'	Admission to neurosurgery
GCS motor score recorded	65%	89%	76%	94%
GCS motor score testable	62%	82%	62%	72%
Full GCS recorded	65%	89%	75%	93%
Full GCS testable	61%	77%	49%	56%

Twenty-four percent of cases were recorded as obeying commands according to the GCS motor score on at least one of the four assessments.

At time of admission to the Neurosurgical Unit, GCS was ≤ 8 in 329 subjects, 9–12 in 162 subjects and 13–15 in 75 subjects, the GCS was untestable in 371 subjects and not recorded in 68 subjects.

Admission CT Findings

The appearances on the first CT scan after admission were classified according to the Traumatic Coma Data Bank (TCDB) categories [26]. Twelve percent were class I (normal), 28% class II (diffuse injury), 10% class III (diffuse injury with swelling), 2% class IV (diffuse injury with shift), and 48% were classified as having a 'mass' lesion. Subarachnoid haemorrhage was identified in 40% of cases and intraventricular haemorrhage was identified in 14% of cases. In total 897 patients had data on a further 'final' or 'worst' CT scan as well as their admission scan, and these data are being presented fully in a separate report.

Early Complications

Twenty percent of patients were recorded as having minor extracranial injuries, and 36% were recorded as having major extracranial injuries, defined as an injury which in itself would have required hospital admission. Fourteen percent of all cases underwent an emergency extracranial operation. Early complications were recorded as hypoxia (27%), hypotension (22%) and hypothermia (6%), and 35% of patients underwent an intracranial operation (other than the placement of an ICP catheter or transducer) within the first 24 hours following injury.

Management and Monitoring

Ventilation was used in 78% of patients, ICP, jugular SVO_2 and invasive blood pressure monitoring were used respectively in 37%, 18% and 68% of patients.

Delayed Complications

Intracranial infection was reported in 8 patients (1%), and other intracranial complications of delayed haematoma (after 24 hours), raised ICP and seizures were reported respectively in 11%, 28% and 7% of patients. Life threatening systemic complications classified as respiratory, cardiovascular, metabolic and infection were reported respectively for 24%, 12%, 5% and 13% of subjects.

Outcome at six Months

Fifty five centres provided data on Glasgow Outcome Score (GOS) at six months for 796 subjects. These were 94% of the 847 cases initially reported from these centres. One hundred and fifty eight (76%) of the remaining 209 cases without data on six month GOS came from 12 centres which were unable to supply any data on six month outcome in any patient. Therefore, in the 55 centres able to provide information on six month outcome, the data were 94% complete. The features of the cases in the 12 centres that did not provide outcome data were broadly similar to those in the 55 centres reporting outcome. Furthermore, in the latter centres, the initial features of the cases with and without outcome data were very similar.

Of the 796 patients whose GOS was available at six months, 244 (31%) were dead, 20 (3%) vegetative, 124 (6%) severely disabled, 159 (20%) moderately disabled, and 249 (31%) were considered to have made a good recovery. Thus, the combination of the last two groups into a 'favourable' outcome occurred in 51%.

Severity Subsets

The criteria for inclusion of patients included patients with 'moderate' (GCS 9–12) as well as severe (GCS ≤ 8) head injuries. Identification of severe cases was complicated by the variability in data available at the various initial time points, in particular data being 'missing' because of intubation, paralysis and ventilation. For comparisons within this survey and with previous series we identified three subsets of patients:

Table 4. *Outcome at Six Months in Subjects Grouped by 'Overall' Initial Severity. Severity Subsets were Defined from Data at all 4 Early Points (see Text). Figures are Numbers of Subjects (%)*

Severity subset	Total	Dead	Vegetative	Severe disability	Moderate disability	Good recovery
Severe	481	192 (40%)	17 (4%)	78 (16%)	93 (19%)	101 (21%)
Intermediate	145	32 (22%)	2 (1%)	20 (14%)	27 (19%)	64 (44%)
Moderate	128	11 (9%)	0 (0%)	18 (14%)	31 (24%)	68 (53%)
Unclassified	42	9 (21%)	1 (2%)	8 (19%)	8 (19%)	16 (38%)

Severe cases ($n = 583$) were composed of: a) all those with GCS 3–8 on admission to the neurosurgical unit (NSU) ($n = 329$), b) those other patients whose GCS at admission to NSU was untestable or not recorded and who had at least one previous observation of a GCS 3–8 and none of a higher GCS ($n = 254$).

The *moderate* group had a GCS of ≥ 9 on admission to NSU and no other recording of a GCS of < 9 ($n = 171$).

A third group of '*intermediate*' severity cases ($n = 192$) did not have a GCS of 3–8 at admission to NSU but had, on other occasions at least one GCS of 3–8 and at least one of ≥ 9. In 59 patients there were insufficient data on GCS to make any sensible classification.

Patients classified as severe in this way, in comparison with the pooled intermediate and moderate groups, were younger (median age 34 years versus 42 years), more often a vehicle occupant (35% versus 21%) more often admitted directly to a hospital with a neuro unit (45% versus 40%), had a higher frequency of major extracranial injury (41% versus 28%), of an intracranial operation in the first 24 hours (37% versus 30%), and their CT scans were less often normal (10% versus 16%) and more often showed diffuse swelling (13% versus 6%) or traumatic subarachnoid haemorrhage (47% versus 32%). They were more often ventilated (92% versus 56%), had invasive monitoring of blood pressure (80% versus 48%), or intracranial pressure (43% versus 24%). Thirty six percent of the severe group had bilateral non-reacting pupils at admission to NSU, in comparison with 7% for the intermediate/moderate groups. The outcomes in these groups are shown in Table 4. The proportions with a 'favourable' outcome at six months were: severe, 40%; intermediate, 63%; moderate, 77%; and unclassified, 57%.

Comparison of Data from Different Areas of Europe

There were data from a sufficient number of subjects for a country based analysis in only some cases (ie Germany, UK, Italy, France and Spain), and other countries were grouped arbitrarily by region of Europe (Scandinavia and Benelux). There were no major differences in the data from these areas for subjects' ages or sex distribution but several differences in distribution that were significantly different were noted (Table 5).

1. The frequency of secondary transfer to the hospital with the neuro unit ranged from 35% in the Benelux countries to 75% in the UK ($p < 0.001$).
2. There were substantial differences amongst countries in the cause of injury ($p < 0.001$). The proportion who were injured as a vehicle occupant ranged from 11% in the UK to 48% in the Benelux countries, and of those who fell under the influence of alcohol from 1% in Spain to 33% in Scandinavia.
3. The proportion of the subjects with a major extracranial injury ranged from 24% in Scandinavia to 53% in the Benelux countries ($p < 0.001$).
4. There were marked differences in admission CT findings amongst the countries ($p < 0.001$). The proportion of patients with a normal CT scan ranged from 4% in Scandinavia to 10% in France, and those with swelling from 7% in Spain to 18% in Italy. The proportions with subarachnoid haemorrhage ranged from 33% in the UK to 57% in Spain ($p < 0.001$).
5. The proportion of the subjects who had an intracranial operation in the first 24 hours ranged from 18% in the Benelux to 53% in Germany ($p < 0.001$).
6. The frequency of the use of ventilation ranged from 53% of subjects in France to 88% in Germany, of invasive blood pressure monitoring from 31% in France to 89% in Scandinavia and of intracranial pressure monitoring from 5% in France to 53% in Spain ($p < 0.001$ in each case).
7. The proportion of subjects with a severe injury (as defined above from the data available on GCS at the four early time points) ranged from 42% in the

Table 5. *Comparison of Features of the Patients from Different Parts of Europe*

	Germany	UK	Italy	France	Spain	Scandinavia	Benelux countries
Sample size	241	219	184	95	90	80	67
Indirect transfer	50%	75%	56%	66%	41%	65%	35%
Age (median)	41	38	35	39	35	41	32
Male	68%	78%	78%	69%	76%	79%	68%
Type of injury							
vehicle occupant	27%	11%	42%	26%	43%	31%	46%
fall	14%	20%	2%	11%	1%	33%	4%
Major extracranial injury	31%	27%	52%	26%	52%	24%	53%
Initial CT scan findings							
normal	10%	16%	12%	16%	13%	4%	11%
swelling	10%	11%	18%	4%	4%	8%	11%
subarachnoid haemorrhage	34%	23%	56%	50%	57%	39%	42%
Intracranial operation within 24 hours	53%	25%	27%	23%	33%	49%	18%
Ventilation	88%	68%	82%	53%	87%	87%	75%
Blood pressure monitoring	77%	60%	72%	31%	72%	89%	75%
ICP monitoring	37%	37%	35%	6%	53%	52%	39%
Initial severity classification							
severe	60%	42%	66%	48%	68%	67%	57%
intermediate	18%	34%	14%	12%	16%	20%	10%
moderate	16%	20%	15%	36%	11%	5%	21%
unknown	7%	5%	5%	4%	6%	7%	12%
Glasgow outcome scale at 6 months							
unfavourable	54%	43%	58%	32%	57%	44%	51%
favourable	46%	57%	42%	68%	43%	56%	49%
Favourable outcome in severe subset	37%	42%	34%	51%	33%	49%	35%

UK to 68% in Spain and Scandinavia, and of those with a moderate injury from 5% in Scandinavia to 36% in France. ($p < 0.001$).

8. The proportion of subjects with a 'favourable' outcome ranged from 42% in Spain to 68% in France ($p = 0.001$).

When analysis was restricted to patients with a 'severe' injury, significant differences remained in type of injury, presence of major extracranial injury, intracranial operation within 24 hours, CT scan findings and presence of subarachnoid haemorrhage, use of invasive monitoring of blood pressure and intracranial pressure, but not in frequency of ventilation. The proportion of favourable outcomes ranged from 33% in Spain to 51% in France but this result was now not significantly different across the countries ($p = 0.33$).

Present and Previous Series of 'Severe Head Injuries'

There are three previous series, compiled through inter-centre collaboration, of large numbers of patients regarded as having suffered a severe head injury, which invite comparison with the data in severe injuries gained in this study (Table 6).

The International Data Bank

Jennett and colleagues in 1977 [15] reported the feature of the first 700 cases entered into the so-called 'International Data Bank' from centres in the UK (Glasgow), the Netherlands (Rotterdam and Groningen) and the USA (Los Angeles County Hospital). The series had been collected primarily to investigate the prognosis of coma (no eye opening, no comprehensible verbal response and not obeying commands) known to have persisted for at least 6 hours. Subsequently, these centres were joined by a second USA centre (San Francisco General) and over 18 years a total of 2978 cases were collected. Only limited aspects of the full data set have been reported [28]. We therefore have performed a new analysis and features of the complete series are presented in Table 7.

The USA National Traumatic Coma Data Bank

Marshall *et al.* [23] described the organisation of a multicentre study in the USA. Six centres participated in the pilot phase, and four in the subsequent full phase. The criteria for entry was a GCS of 8 or less after non surgical resuscitation, or deteriorating to a

Table 6. *Entry Criteria Applied in Current Study and Three Previous Reports*

	EBIC core data survey – severe cases	International data bank full series	USA traumatic coma data bank	UK four centres study
Period	February 1995 – April 1995	1968–1985	January 1984 – September 1987	1986–1988
Age	adult (>16 years)	any	any	any
GCS	severe (≤ 8) at admission to NSU. If NSU GCS not available, at least one of Pre-Hospital, A&E and Post-resuscitation ≤ 8 and none > 8.	coma ($E = 1, V \leq 2, M \leq 5$), sustained for 6 hours	severe (≤ 8) post-resuscitation	coma ($E = 1, V \leq 2, M \leq 5$)
Time window	admitted to NSU within 24 hours of injury	none	within 48 hours of injury	admitted to NSU within 72 hours of injury
Sample size	583	2978	746 (+284 GSW or DOA)	988

GCS of 8 or less. The criteria had to be fulfilled within 48 hours of injury, but the duration that impaired consciousness should be sustained was not specified. Outcome was planned to be assessed at discharge and 6, 12 and 24 months after injury. Foulkes *et al.* [9] reported the initial features and Marshall *et al.* [24] the outcome in 746 cases. The numbers actually assessed at the different time points was not stated; time of follow up to last contact for survivors ranged from 11 to 1199 days, with a median of 674 days; two thirds were followed for over 1 year.

The British Four Centre Study

Murray *et al.* [30] described 1025 patients collected in the Neurosurgical Units in Glasgow, Edinburgh, Liverpool and Southampton in a study of the clinical application of a prognostic system [2] that had been developed from the data in the International Data Bank. The patients had either been in coma at some time in the neurosurgical unit, including durations of less than 6 hours, or had undergone evacuation of an acute traumatic intracranial haematoma. In a further report Murray *et al.* [29] described the relationship between intensity of management and outcome in this series. The features of these cases are shown in Table 7.

Findings in Different Series

The criteria for recruitment to the series are shown in Table 6, demographic and injury characteristics in Table 7, CT scan findings in Table 8, different aspects of management in Table 9, and distribution of outcomes in Table 10. Notable features of these comparisons are considered in the discussion.

Discussion

The "Core Data Bank Survey" showed that it is feasible to run a major international research project within the framework of the European Brain Injury Consortium, and indeed, the success of the survey was a major factor promoting the constitution of EBIC on a formal basis. The study was inexpensive, as centres were offered minimal funding, and its success depended upon the commitment of the participants. Nevertheless, the data returned were generally of high quality with regard to completeness and credibility of information.

Quality of Data Obtained

For data in the acute stage, more than 90% of potential observations were completed and data checking revealed few recordings outside specified ranges or showing obvious inconsistencies requiring referral back to the investigator for clarification. No attempt could be made to confirm the accuracy of the data by comparison with original case records. This process is extremely expensive in time and personnel and is customarily performed only in trials of pharmacological agents conducted with a view to registration with licensing authorities. Nevertheless, the *credibility* of the data obtained is supported by the internal coherence and consistency of the findings.

For those centres that agreed to provide follow-up, information was obtained from 94% of their patients, a rate that compares favourably with previous series [24, 35].

There was a coherent pattern between cause of injury, pattern of injury sustained and management.

Table 7. *Demographics and Characteristics of Injury in EBIC Survey and Three Previous Series of Severe Head Injuries*

	EBIC core data survey – severe cases	International data bank full series	USA traumatic coma data bank	UK four centres study
Sample size	583	2978	746	988
Direct admission to neurosurgical hospital	45%	not recorded	61%	12%
Age mean	41	36	–	34
SD	20	21	–	21
median	35	32	25	29
range	2–92 (10 aged ≤ 14)	0–89	–	0–87
interquartile range	23–58	18–53	–	17–51
Male	73%	79%	77%	75%
Type of injury				
motor vehicle occupant	35%	17%	64%	14%
pedestrian	13%	25%	11%	30%
RTA other (or unknown)	9%	14%	–	13%
work	5%	4%	–	4%
assault	4%	7%	5%	7%
domestic	11%	9%	–	9%
sport	3%	2%	–	4%
fall under influence of alcohol	11%	14%	16%	16%
other	10%	8%	–	3%
Alcohol involved	not recorded	35%	40%	not recorded
Major extracranial injury	41%	33%	not recorded	39%

Table 8. *Findings in First CT Scan After Admission in EBIC Survey and Three Previous Reports*

	EBIC core data survey – severe cases	International data bank full series	USA traumatic coma data bank	UK four centres study
Patients with data	575	1263	726	980
Classification				
1. Diffuse injury without signs of brain swelling or raised ICP	37%	26%	32%	25%
2. Diffuse injury with signs of brain swelling or raised ICP	15%	19%	25%	12%
3. Mass lesion: evacuated	28%	37%	37%	36%
4. Mass lesion: non-evacuated	20%	18%	5%	27%
Traumatic subarachnoid haemorrhage	47%	not recorded	39%	not recorded

Table 9. *Aspects of Management of Severe Head Injuries in the EBIC Survey and Three Previous Reports*

	EBIC core data survey – severe cases	International data bank full series	USA traumatic coma data bank	UK four centres study
Sample size	583	2978	746	988
Intracranial operation (other than burr hole for ICP monitoring)	37%*	47%	33%	39%
Ventilated	92%	45%	–	66%
ICP monitored	43%	35%	–	31%
Arterial pressure monitored	80%	not recorded	–	36%

* Within first 24 hours after injury.

Thus, patients injured in a road vehicle accident more often had complications associated with high velocity injury, for example major extracranial injuries and an extracranial operation, and more often had complications of hypoxia and hypotension. Likewise, in common with previous reports [11, 12, 43], they less often had an intracranial mass lesion requiring an operation. There was also coherence between the pattern of in-

Table 10. *Glasgow Outcome Scale at six Months of Subjects Reported in the EBIC Survey and Three Previous Series*

	EBIC core data survey – severe cases	International data bank full series	USA traumatic coma data bank	UK four centres study
Sample size	481	2959	746	976
Glasgow outcome scale				
dead	40%	49%	36%	39%
vegetative	4%	2%	5%	1%
severe disability	16%	13%	16%	17%
moderate disability	19%	15%	16%	16%
good recovery	21%	20%	27%	24%
moderate/good (unspecified)	–	–	–	3%
"Favourable" outcome (moderate disability or good recovery)	40%	35%	43%	42%
Severe disability in survivors	29%	27%	27%	28%

jury reported to have been observed in the CT scan and the recording of performance of an intracranial operation.

Severity of Injury

This is the first report of a large prospective series of patients in neurotrauma centres that incorporates subjects considered to have either a moderate or a severe injury.

Although interrelationships would be expected between severity of injury features such as investigation findings, complications, management and outcome, in practice it proved difficult to apply either well established simple distinctions between severe and moderate injury or more refined discriminations. This was as a result of the frequent unavailability of information due to the use of sedation and paralysis, a problem reported by other workers [22]. Although this was least often a problem in observations recorded before arrival at hospital, data from this phase were not available for a third of subjects. Even when 'pre-hospital' clinical state is available it can be a misleading index of prognosis [45]. Conversely, data were available for almost all subjects at the "within hospital" time points but the yield of information was offset by the substantial portion of unassessable items. The high proportion of patients in whom a full GCS could not be obtained at the time of admission to the neurosurgical or neurological unit illustrates the potential problem in using clinical responsiveness at this stage as an inclusion criterion for trials.

The time points and clinical data chosen as a basis for categorising severity of head injury in previous studies have varied considerably [22]. Time points include: on arrival at hospital [10], or at the neurosurgical department [3], after completion of 'non-surgical' resuscitation [23, 27, 46], within four hours of injury [25] or the persistence of features of impaired consciousness for intervals of from six hours [4, 15, 31, 36] to 12 hours [8], 24 hours [1], 48 hours [9, 23] and 72 hours [30]. Approaches used to allow for missing data have included allocating a 'pseudo score' of 1 for the verbal portion of the GCS in an intubated patient [23], but this results in a loss of information in severe cases [17, 33] and may be especially misleading in moderate injuries.

We found it was neither appropriate nor valid to apply a categorisation of severity on the basis of information at any specific single time point. The approach we devised took maximum advantage of whatever information was available from each of the four time points and enabled us objectively to allocate categories of severe, intermediate or moderate to 94% of patients reported. We could then use these groups to relate to other data obtained from the whole series, to compare patients in different geographical areas, and to relate findings from this study to previous reports.

The group we subsequently classified as severe proved to be younger, more often had been injured as a motor vehicle occupant, were more often directly admitted to hospital with a neurosurgical unit and more often had an major extracranial injury. Their CT scans were less often normal and more often showed swelling, subarachnoid haemorrhage and intracranial mass lesions. They more often had an intracranial operation

and more often received intensive management by the use of ventilation and invasive monitoring of blood pressure and intracranial pressure.

Characterisation of groups by the method we used to classify initial severity was also reflected in differences in outcome. Mortality in those classified as moderate or intermediate was less than in the severe cases and there was a corresponding increase in the proportion categorised as an independent, 'favourable outcome'. Nevertheless, it was noteworthy that disability was common in all classes of severity. Indeed, the proportions of individuals categorised as severely or moderately disabled did not differ significantly across the spectrum of early severity, being 36%, 32%, 38% and 38% respectively in the severe, intermediate, moderate and unclassified groups.

The coherence of patterns observed in the different groups provided a reasonable background to investigate the patterns observed in the different regions in the current survey and to relate the present findings to previous reports.

Geographical Variations

The survey was not planned as a comprehensive, rigorous, epidemiological study, completely representative of the practice of head injury care in the different countries. Nevertheless, in the large number of participating centres and the large number of total patients reported, significant differences in patients and practice were observed that merit cautious comment. In order to avoid focusing on individual centres, we grouped units either according to countries or, where the numbers of patients reported were too small, into larger geographical units.

The findings in different areas present a complex pattern, but certain points can be noted. There were broad similarities among *Italy, Spain* and *Benelux* countries in terms of the patients having a relatively younger age distribution, a high occurrence of injury as a vehicle occupant, with associated major extracranial injuries, and frequent admission directly to a hospital with a neuro unit. The proportions of subjects judged to be severe were also high in Italy and Spain and outcome was less often favourable in Spain, Italy and Benelux countries, in all cases and in the severe subset. The *Scandinavian* subjects, and to some extent those in *Germany*, were similar to those in Spain, Italy and Benelux in terms of frequency of severe injury but were less often multiply injured and were more often transferred secondarily to the hospital with the neurosurgical unit, and more often had an intracranial operation. In the *UK* and *France* subjects were relatively older, but less often a vehicle occupant, were most often transferred to the neurosurgical unit from another hospital, had a low rate of major extracranial injury and of intracranial operation, were less often 'severe' and had a higher rate of favourable outcome.

Underlying some of these variations appeared to be differences in the proportion of patients taken directly to a hospital with a neurosurgical unit or transferred, presumably selectively, after initial assessment and management in another hospital, and along with this, differences in patterns of injury and severity of brain damage of patients in neurosurgical units in different countries. Differences in approach to management are being analysed further and, since this study, guidelines for use in Europe have been published [19].

Comparison with Previous Series

The present and the three previous series referred to contain a total of 5,717 patients with head injury treated in a neuroscience unit. For detailed analysis we have focused on those patients in the present series graded as having a severe injury ($n = 583$), for whom outcome was known in 481. The comparisons made show many similarities but also differences that may, in part, reflect variations in criteria for recruitment to the different series and also changes in management over the last three decades.

Demography

Very similar proportions of patients in the four series were male (73–79%). The proportions injured in a road traffic accident were very similar in the original International Data Bank, in the UK Four Centres study and the current survey (56–57%) whereas in the North American series many more (75%) received their injury as a result of a road traffic accident. The proportions with major associated extracranial injuries were similar (33–41%) in the International Data Bank and the UK and European surveys; these data were not reported for the North American study (Table 7).

Demographically, the most clear distinction between the present and previous series was in the age of the subjects. In the EBIC survey, the entry criteria specified an age of 16 years or older and as a consequence, the median age was 35 years whereas in the

North American Coma Data Bank, the median age was 25 years, and was 32 in the International and 29 in the UK surveys, in which respectively 18% and 21% patients were aged 15 years or less. The focus on adults in the EBIC survey reflected the interest in studies of pharmacological interventions, from which children are customarily excluded.

Comparison of the CT scan findings in the different series is hindered by changing approaches to classification of scan that have evolved over the last two decades, indeed, many of the first 700 patients in the International Data Bank were studied before CT scanning was available. Recognition of the importance of radiological signs of cerebral compression and raised intracranial pressure (obliteration of the third ventricle and basal cisterns) [37, 41, 42] and of traumatic subarachnoid haemorrhage [6] has increased the focus on these items in more recent series.

A 'mass' lesion was present in between 42% of subjects in the American series to 63% of the UK cases (Table 8). This high proportion in the latter may reflect the arrangements for selective admission of severe injuries seen in the UK study. The proportion of patients considered to have a diffuse injury complicated by swelling or shift differed between the North American (25%) and present European series (12%), which classified findings according to the same system. One explanation for the difference may be observer variation in CT scan interpretation [7]. Another is uncertainty about exactly when the classification is applied; this was not specified in the North American series and in some subjects may have been applied taking findings in later CT scans into account. In the present series classification was made prospectively, on the first CT scan and this may account for the lower occurrence of signs of secondary swelling and raised ICP. On the other hand traumatic subarachnoid haemorrhage was reported more frequently in the current series; perhaps reflecting greater appreciation of the significance of this finding and the interest of treatment of subarachnoid haemorrhage by pharmacological methods [6, 13, 16, 18].

Management and Complications

Around one third of the patients underwent an early intracranial operation in the present, the UK and North American series (33–39%) but this was performed in 47% in the International series (Table 9). This difference may reflect recruitment to the International survey having required coma to persist for more than 6 hours, or may reflect changing referral policy, with more patients not directly requiring neurosurgical operation being referred to neurotrauma units.

There were clear variations in aspects of 'medical' management in the different series. Ventilation, used in only 24% of the original 700 patients in the International Data Bank, was employed in 45% of the full series, 66% in the subsequent UK series and in 92% in patients the present survey. Although the use of invasive arterial monitoring was not recorded in the earlier series, it rose from 36% in the UK study to 80% of severe cases in the European survey. In contrast, there was less difference in the frequency with which intracranial pressure was reported to be monitored: 35% of subjects in the International Data Bank, 31% in the UK study, and 43% in the current survey. Conversely there was decreasing use of corticosteroids and data on this was not even recorded in the European survey. The rates of utilisation of ventilation and of monitoring of ICP are not stated in the reports of the North American Traumatic Coma Data Bank.

The observed incidence of hypotension (22%) is lower than the incidences reported from the Traumatic Coma Data Bank (29% [32] and 30% [5]). It is slightly higher than the 15% reported from the recent International Tirilazed study [25] which considered only events in the first four hours. In the current series, the reported incidence of hypoxia is very similar (27%) to the report from the Traumatic Coma Data Bank (26%) [5]; in the International Tirilazad trial the incidence in the first four hours was again lower (15%) [25].

Outcome

Outcome was broadly similar in the North American, UK and present European series. Mortality ranged from 36–40%, and favourable outcome from 40–43% (Table 10). The higher mortality in the full International Data Bank (49%) presumably reflects these patients having been more severely injured because they were in coma for at least 6 hours. However, this difference was restricted to mortality and the distributions of outcomes in survivors was remarkably similar across the different series. Thus, just over one quarter of survivors were severely disabled and between 35% and 43% of the overall population had a favourable outcome. This observation supports the view that the major influence of initial severity may be on mortality and that, if survival occurs, disability is

much more difficult to predict from early features. It also supports the consistency of the Glasgow Outcome Scale in describing distribution of outcome in large series; its consistency when applied to individual subjects [21] has been improved recently by a new structured method [44].

Conclusion

It has proved possible, with minimal resources, to conduct an observational study providing a large amount of data, of apparently high quality, about severely and moderately head injured adults treated in major European neurotrauma centres. The data show broad consistency in the features of such patients across Europe and between the findings in this and previous series. Nevertheless the study has also shown several differences and highlights the need for caution in making comparisons between patients studied either at different times or in different regions.

Two major sources of differences in reported series of head injuries are aspects of organisation and management concerning referral and admission policy and variations in causes, patterns and severity of brain damage and extracranial injures of subjects in different centres. This difference in management policies and arrangements for neurosurgical services leads to different proportions of patients being either transported directly to a hospital with a neurosurgical centre or referred selectively after admission and assessment in another hospital. These influences are readily analysed whereas the problems encountered in analysing patterns of severity within this series of patients and previous series have highlighted the difficulties in applying classifications of early severity, as a result of the loss of observations occasioned by the use of sedation and ventilation. Further analyses are in progress, concerning variations in injury pattern, severity, management and outcome. An observational study, even performed prospectively and to a high degree of quality, can be expected to provide no more than tentative conclusions and hypothesis for further study.

A major conclusion of the present study is that definitive information, upon which to base decisions about the choice of different systems of management, is still likely to result only from data obtained in prospective, rigourously controlled investigations. The success of the survey shows that the European Brain Injury Consortium is potentially well founded to meet the challenge of performing such investigations, in pursuit of its goal of improving the treatment of head injured patients.

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Comment

This is a multi-authored, multi-institutional survey of the current treatment of head injury in Europe and Britain. It is contrasted with the North American Traumatic Coma Data Bank and the International Data Bank which involves the UK, the Netherlands, and the USA. Differences in triage and early management are reflected. This is good baseline information from which other papers will be derived.

The survey includes over 1000 patients gathered from over 50 institutions. The data are not contaminated by pharmacologic trials. Copies of the EBIC questionnaire are available from Professor Murray on request.

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