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THE MANAGEMENT OF PATIENTS WITH INTRADURAL POST-TRAUMATIC MASS LESIONS: A MULTICENTER SURVEY OF CURRENT APPROACHES TO SURGICAL MANAGEMENT IN 729 PATIENTS COORDINATED BY THE EUROPEAN BRAIN INJURY CONSORTIUM

OBJECTIVE: Controversy exists about the indications and timing for surgery in head injured patients with an intradural mass lesion. The aim of this study was to survey contemporary approaches to the treatment of head injured patients with an intradural lesion, placing a particular focus on the utilization of decompressive craniectomy.

METHODS: A prospective international survey was conducted over a 3-month period in 67 centers from 24 countries on the neurosurgical management of head injured patients with an intradural mass lesion and/or radiological signs of raised intracranial pressure. Information was obtained about demographic, clinical, and radiological features; surgical management, and mortality at discharge.

RESULTS: Over the period of the study, data were collected about 729 patients consecutively admitted to one of the participating centers. The survey included 397 patients with a severe head injury (Glasgow Coma Scale [GCS] 3–8), 155 with a moderate head injury (GCS 9–12) and 143 patients with a mild head injury (GCS 13–15). An operation was performed on 502 patients (69%). Emergency surgery (<24 h) was most frequently performed for patients with an extracerebral mass lesions (subdural hematomas) whereas delayed surgery was most frequently performed for an intracerebral hematoma or contusion. Decompressive craniectomy was performed in a substantial number of patients, either during an emergency procedure (n = 134, 33%) or a delayed procedure (n = 47, 31%). The decompressive procedure was nearly always combined with evacuation of a mass lesion. The size of the decompression was however considered too small in 25% of cases.

CONCLUSION: The results provide a contemporary picture of neurosurgical surgical approaches to the management of head injured patients with an intradural mass lesion and/or signs of raised intracranial pressure in some Neurosurgical Units across the world . The relative benefits of early versus delayed surgery in patients with intraparenchymal lesions and on the indications, technique and benefits of decompressive craniectomy could be topics for future head injury research .

KEY WORDS: Decompressive craniectomy, Intradural mass lesions, Surgical management, Traumatic brain injury

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There is controversy about the indications and timing for surgery in the management of head-injured patients. This applies especially to those with intradural lesions such as an acute subdural hematoma (29, 33), parenchymal brain contusions and/or an intracerebral posttraumatic hematoma (3, 5). These controversies reflect the lack of high quality data relating surgical approach to outcome. Consequently, the uncertainties in the management of a patient with an intradural lesion are not satisfactorily dealt with in pub-

lished guidelines. The international guidelines of the American Association of Neurological Surgeons/Brain Trauma Foundation (4) do not refer to indications for surgery and guidelines issued in Europe only contain general suggestions (17, 27). One of the sources of uncertainty about the management of traumatic intradural lesions is the lack of clear criteria for interpretation of computed tomographic (CT) scan findings in a way that is relevant to clinical and surgical decision making. The method of Marshall et al. (18) has proved a useful classification of morphological severity but was not developed as a discriminator for surgical indications.

Different interpretation of definitions, difficulties in volumetric measurement of intraparenchymal lesions and changing views on surgical indications complicate comparability of series. The lack of criteria to determine the comparability of patients is illustrated in a recent paper from the European Brain Injury Consortium (EBIC) (30) that showed favorable outcome in 45% of patients with evacuated mass lesions versus 42% in patients with non-evacuated mass lesions.

The need to reassess surgical approaches has been highlighted by the recent resurgence of interest in decompressive craniectomy (13, 22, 26) in the management of severely head injured patients. Sometimes decompression is done as a primary procedure, at the time of an initial operation to evacuate a contusion or subdural hematoma (22); in other cases, decompression is performed only as a lifesaving or secondary salvage procedure in patients with severe brain swelling and intracranial hypertension (26, 32). It is, therefore, very difficult to differentiate between the effects of the bony decompression for treatment of diffuse brain injury with swelling and results of combined decompressive craniotomy with removal of mass lesions. Moreover, even if done, there is no agreement about if decompressions should be unilateral, bilateral or varied according to the lesion's location and nature (13, 22, 25, 26, 32).

We report the findings of a prospective, multicenter study of the management of a large cohort of head-injured patients with intradural lesions (acute subdural hematomas and brain parenchymal damage) with a particular focus on the use of external bony decompression. The results provide a contemporary picture of practice in neurosurgical units and a framework for further investigation.

PATIENTS AND METHODS

We prospectively collected data over a 3-month period in 2001 about head injured patients with a mass lesion and/or radiological signs of raised intracranial pressure (ICP) who were treated in one of 67 centers in 24 countries (see Appendix). The patients were either admitted to the neurosurgery unit within 24 hours after injury (95%) or were transferred later (within 72 hours [5%]) after secondary deterioration associated with a change in their CT picture from one of a diffuse injury to a mass lesion. Inclusion was based on radiological criteria irrespective of the Glasgow Coma Scale (GCS). The primary criterion was the presence of an intradural lesion with a high or mixed density component greater than 25 ml and secondary criteria, the presence of radiological signs of shift and/or raised intracranial pressure as determined by the participating investigators. Details of the inclusion and exclusion criteria are summarized in *Table 1*. In the case of bone decompression, we suggested to quantify the extend of the decompression by the method proposed by Munch et al. (22). The survey was organized by the EBIC Coordinating Centre at the University of Glasgow, Scotland.

Data Collection

The study protocol, data forms, and guidelines for form completion were made available to all investigators on a dedicated website (www.ebic.it). We used a modified version of the data collection forms used in a previous EBIC survey (23). Data collection was done either via the Internet (Italian and Spanish centers) or via paper forms subsequently sent to the EBIC coordinating center. The GCS was determined at three time points: prehospital, on arrival at the first hospital, and at admission to the Neurosurgical Unit (NSU). For the "first reliable GCS," we used the first GCS recorded at any time point. Specific attention was focused on details of surgical procedures. These were differentiated into "emergency" surgery and "delayed" surgery. Emergency surgery was defined as an operation within 24 hours after injury and delayed surgery as a later operation. Data relating to the early management were returned within one month of admission. These data included death at discharge from the emergency Hospital.

Statistical Analysis

On the basis of the previous EBIC survey (23), we estimated that the cohort should contain at least 600 patients. As the aims of the study were essentially descriptive, few formal

TABLE 1. Enrollment criteria[a]

Inclusion criteria
Presence of a high density lesion with a volume > 25 ml on CT examination and/or radiological signs of raised ICP
Midline shift > 5 mm
Compression/obliteration third ventricle
Compression/obliteration of basal systems
Compression of the ipsilateral ventricle
Dilatation of the contralateral ventricle
Exclusion criteria
Inability to obtain hemodynamic and respiratory stability
Injuries owing to a penetrating object (gun shot wounds and stab injuries)
CT signs of diffuse injury without mass effect
Pure (i.e., not associated with intradural mass lesions) epidural hematomas
Rebleeding in a chronic subdural hematoma

[a] CT, computed tomographic; ICP, intracranial pressure.

statistical comparisons have been made. Categorical data are tabulated and data on continuous variables are summarized using means, standard deviations and percentiles. Factors associated with the use of decompressive craniectomy are assessed using χ^2 tests and t tests as appropriate.

Study Limitation

As in previous studies (23, 30), data collection was conducted with very limited budget. Therefore, no central CT reading was provided. CT classification and the estimated area of decompression were coded as scored by our investigators.

RESULTS

Patient Characteristics

A total of 729 patients were entered by the 67 centers participating in the study, see appendix. Demographic and clinical features are shown in *Table 2*. The mean age of the patients was 46 years (range, 2–95). A large proportion of patients (56%) were admitted to the NSU after secondary referral. Road traffic accidents caused the injury in 300 patients (43%).

The first reliable Glasgow showed 397 (55%) patients with a GCS 3 to 8, 155 (22%) patients with a GCS 9 to 12, 143 (20%) patients with a GCS 13 to 15 and 21 (3%) patients with a GCS untestable. The median value was 7 and interquartile range 5 to 12. There was a prevalence of severe and moderate head-injured patients in this series, but the high percentage (20%) of mild head injury is somewhat surprising.

The findings in the initial CT are presented in *Table 3*; 517 patients (73%) had a mass lesion at this stage. Traumatic subarachnoid hemorrhage was present in 368 patients (54%) and intraventricular hemorrhage in 96 patients (14%). Midline shift was present in 453 (62%) patients. The mean shift was approximately 9mm. Worsening of CT findings was noted in 273 (39%) of patients.

TABLE 2. Features of patients included in the European Brain Injury Consortium study[a]

Characteristic	No.
No. of patients	729
No. of centers	67
Referral (n = 673) secondary referral	376 (56%)
Age (n = 724)	
Mean (SD)	46.2 (20.8)
Median (range)	45 (2–95)
Interquartile range	28–64
Gender (n = 725)	
Male	570 (79%)
Cause of injury (n =703)	
Road traffic accident	300 (43%)
Work	47 (7%)
Assault	53 (7%)
Domestic	100 (14%)
Sport	19 (3%)
Fall under influence of alcohol	91 (13%)
Other	93 (13%)
First reliable GCS (n = 716)	
Median (range)	7 (3–15)
Interquartile range	5–12
Severe (<8)	397 (55%)
Moderate (9–12)	155 (22%)
Mild (13–15)	143 (20%)
Untestable	21 (3%)
GCS motor NSU (n = 708)	
Median (range)	4 (1–6)
Interquartile range	2–5
Untestable	94 (13%)
GCS total NSU (n = 708)	
Median (range)	7 (3–15)
Interquartile range	5–12
Untestable	171 (24%)
Pupillary reactivity (n = 696)	
At least one nonreactive pupil	285 (41%)
Extracranial injuries (n = 657)	
Major	150 (23%)
Hypoxia (n = 711)	
Present	178 (25%)
Hypotension (n = 710)	
Present	115 (16%)
Mortality on discharge	192 (26%)

[a] SD, standard deviation; GCS, Glasgow Coma Scale; NSU, neurosurgical unit. For each variable, percentages are based on the number of patients with the relevant data recorded. The number of patients on whom data were available are reported per variable in brackets; the average number of missing values was 27 (4%).

Surgical Management

Details of operative procedures are presented in *Table 4*. One hundred and four operations were solely for placement of an intracranial pressure monitor and were not considered further; 502 patients (69%) underwent a craniotomy or craniectomy. Of these, 348 (69%) underwent only an emergency operation, 98 (20%) only a delayed operation and 56 (11%) underwent both an emergency and a delayed operation. Almost all operations were for evacuation of a mass lesion, in both emergency surgery (99%) and delayed surgery (83%). In emergency operations, acute subdural hematoma, sometimes associated with brain contusions, was the most frequently evacuated lesion (69%). Acute subdural hematomas without associated contusions were much less frequently removed in a delayed procedure: 169 (93%) cases were treated as emergency, and only 12 (7%) as delayed surgery. In delayed operations, intracerebral lesions (hematoma or contusion), sometimes associated with a subdural hematoma, were the most frequently evacuated lesions (n = 80, 73%). Investigators reported mass effect and lesion size as the main reasons for

emergency surgery. In "delayed" procedures this was different, with the main reason for operation almost equally allocated to increasing intracranial pressure, clinical and radiological deterioration. More than one reason may have been present in some individuals, but this was not recorded.

Decompressive Craniectomy

A decompressive craniectomy was performed in a substantial number of patients, either during an emergency procedure (n = 134, 33%) or a delayed procedure (n = 47, 30%) (*Table 5*). The mean size of decompression performed in the emergency setting was 67 cm^2, and in delayed surgery 80 cm^2. In *Figures 1* and *2*, we reported the areas of decompression. Because we were surprised by the number of small craniectomies reported as "decompressive craniectomies" we have taken 30 cm^2 as a cut-off limit between small and large craniectomies. This limit of 30 cm^2 was arbitrarily taken and it is about half of the reported area (22) sufficient to reduce cistern's compression and midline shift after external decompression. In 43 patients (38 emergency surgeries and 5 delayed surgeries), the size of the decompression was less than 30 cm^2 and the procedure probably consisted only of leaving the surgical bone flap out.

Details of the number, type, size and reasons for these procedures are summarized in *Table 5*. The decompressive procedure accompanied evacuation of a mass lesion in nearly all instances. Thus, decompression was performed in the absence of a mass lesion in only one patient as an emergency procedure, and in only eight patients undergoing delayed surgery. When a decompressive craniectomy was performed during an emergency operation, the indications usually reported were the size of lesion and its mass effect. In contrast, when decompression was carried out during delayed surgery, this was attributed to a measured increase in ICP in almost half of the patients. Clinical or radiological deterioration, without evidence of intracranial pressure, accounted for half of the delayed decompressions.

TABLE 3. Computed tomographic scan characteristics[a]

Characteristic	No.	
Initial CT classification (n = 713)		
Diffuse injury Type I–II	117	(16%)
Diffuse injury Type III–IV	79	(11%)
Evacuated mass lesion	246	(35%)
Non-evacuated mass lesion	271	(38%)
Traumatic subarachnoid hemorrhage (n = 685)		
Present	368	(54%)
Intraventricular hemorrhage (n = 677)		
Present	96	(14%)
Midline shift (n = 471)		
Present	453	(62%)
Mean (SD)	8.9 (5.4)	
CT progression (n = 703)	273	(39%)

[a] CT, computed tomography; SD, standard deviation.

Clinical Features and Performance of Decompression

When decompression was carried out as an emergency, there was an association with more severe clinical status before operation, with more patients having unreactive pupils and more a GCS of 8 or less. In contrast, decompression as a delayed procedure was associated with the patient's age, with those undergoing decompression being younger (mean, 36.5 yr) than those who were not (mean, 46.3 yr).

Early Mortality

Overall, 192 (26%) of the patients studied were reported to have died during acute hospital stay; 131 (68%) of these patients died within 1 week after injury. Of those undergoing operations, 141 (28%) patients died. In those not undergoing surgery, 51

TABLE 4. Details of surgical treatment[a]

Variable	Emergency surgery	Delayed surgery
No. of procedures	404[b]	154[b]
Extradural hematoma	60 (17%)	18 (16%)
Acute subdural hematoma	169 (47%)	12 (11%)
Contusion/intracerebral hematoma	51 (14%)	48 (44%)
ASDH and contusion	79 (22%)	32 (29%)
Other [c]	45	44
Associated decompressive craniectomy	134 (33%)	47 (30%)
Reason for surgery	Mass effect 234 (62%)	Increased ICP 47 (31%)
	Lesion Size 65 (17%)	Radiological deterioration 49 (33%)
	Clinical deterioration 59 (15%)	Clinical deterioration 43 (29%)
	Other 22 (6%)	Other 11 (7%)

[a] ASDH, acute subdural hematoma; ICP, intracranial pressure.
[b] Fifty-six patients underwent both emergency and delayed surgery and are reported in both columns.
[c] Patients operated with a craniotomy, but with a lesion not better specified or with a combination of different lesions; not included in % calculations.

TABLE 5. Decompressive craniectomy[a]

Variable	Emergency surgery	Delayed surgery
No. of procedures	134[b]	47[b]
Isolated procedure	1 (0.7%)	8 (17%)
Inadequate decompression	38 (28%)	5 (11%)
Unknown	15 (11%)	10 (21%)
Adequate decompression	81 (61%)	32 (68%)
Adequate decompression (>30 cm*2*)[c]	Mean (SD) area = 92 (51)	Mean (SD) area = 90 (65)
	Median = 80	Median = 80
Size of decompression	Range = 32–300	Range = 32–361
	IQR = 56–120	IQR = 48–100
Associated surgical treatment		
Extradural hematoma	8 (10%)	3 (9%)
Acute subdural hematoma	36 (44%)	1 (3%)
Contusion/intracerebral hematoma	10 (12%)	8 (25%)
ASDH and contusion	23 (28%)	8 (25%)
Other	4 (5%)	12 (37%)
Reason for surgery	Mass effect 56 (71%)	Increased ICP 14 (45%)
	Lesion Size 8 (10%)	Clinical deterioration 10 (32%)
	Clinical deterioration 11 (14%)	Radiological deterioration 5 (16%)
	Other 4 (5%)	Other 2 (6%)

[a] SD, standard deviation; IQR, interquartile range, ASDH, acute subdural hematoma.
[b] Seven patients were decompressed twice and are included in both columns.
[c] The size of decompression was unknown in 15 patients (11%) who underwent emergency surgery and in 10 (21%) who underwent delayed surgery.

(22%) patients died. Mortality was higher in those who underwent only an early emergency operation (n = 124, 31%) and among these there was a trend for it to be higher in those undergoing decompression (n = 30, 37%). Mortality was lower in those having delayed surgery (n = 32, 21%), either alone or after emergency surgery. In this category, there were only five decompressed patients who died and the numbers are too small to draw any conclusion (*Table 6*).

DISCUSSION

Surgical treatment for head injury is the oldest reported neurosurgical procedure. In the Edwin Smith papyrus ("published" in 1700 BC but referring to 3000-2500 BC), 27 of the 48 reported cases concern a head injury and 11 of these contain suggestions about surgical treatment (1). Even in the Middle Ages, the indications for operation in brain-injured patients were perceived as among the most challenging surgical decisions (9, 10).

In the last quarter of the 20th century, the management of head-injured patients was placed on a much more rational basis. This reflected two main advances. First, a greater understanding of the nature of traumatic brain damage was established (12) leading to an emphasis on interventions to avoid secondary damage. Second, the introduction of cross-sectional CT scan imaging enabled early and accurate diagnosis of intracranial pathology (11, 15). These advances led to very clear improvements in the outcome of patients with head injury, particularly of those with an extradural hematoma (2). Improvements in outcome of patients with an intradural lesion were more modest, and have also reflected in part the advances in intensive care in this period (3). As a consequence, the role and timing of surgery in the management of intradural lesions, and its merits in comparison to intensive medical treatment, continues to be a matter of debate (5).

This study shows that operative intervention remains the major approach used by neurosurgeons in patients with a space-occupying intradural lesion. More than 69% of patients in this study underwent operative intervention. Our data indicate that surgeons are more convinced of the merits of emergency operation in the management of an extracerebral hematoma, thus, 93% of patients with an acute subdural hemotoma were treated with emergency surgery. The apparently high degree confidence of surgeons in the role of early surgery in patients with an extra parenchymal hematoma is soundly based upon pathophysiological principles and immense clinical experience. In particular, there is clear evidence that delay in evacuation of significant epidural hemotoma and subdural hematoma with midline shift until after the onset of clinical deterioration is clearly associated with worsening of outcome (19, 28). Debates about the role of surgery in these circumstances are as relevant as debates about the role of wearing a parachute in the absence of randomized controlled trials of the effects of jumping out of an airplane!

Nevertheless, it should be recognized that there are a considerable number of papers suggesting that in selected in-

TABLE 6. Factors associated with the use of bone decompression in surgical procedures[a]

Early surgery	Decompressive craniectomy	No decompressive craniectomy	*P* value
Age mean (SD)	44.4 (20.0)	47.6 (20.7)	0.20
At least one nonreactive pupil	55 (68%)	139 (43%)	0.0001
GCS ≤ 8	65 (81%)	172 (56%)	<0.001
In-hospital death	30 (37%)	94 (29%)	0.17
Delayed surgery			
Age mean (SD)	36.5 (15.4)	46.3 (20.3)	0.01
At least one nonreactive pupil	8 (25%)	33 (27%)	0.95
GCS ≤8	29 (59%)	57 (49%)	0.30
In-hospital death	5 (16%)	27 (22%)	0.47

[a] SD, standard deviation; GCS, Glasgow Coma Scale. We considered only patients submitted to a decompression of more than 30 cm^2.

stances (small volume, absence of compression or midline shift), epidural (14) and subdural (7, 29) hematomas can be managed conservatively, monitoring progress with repeated CT scanning. Our findings show that surgeons have a more conservative approach towards the management of intraparenchymal brain lesions. One hundred and thirty-three early operations were for evacuation of a contusion or an intracerebral hematoma, but 79 (61%) of these were performed in association with evacuation of a subdural hematoma. Evacuation of contusions was the main reason for delayed surgery (n = 80, 73%).

Advocates of evacuation as an early step base their view on factors such as evidence of the adverse consequences of mass effect, on the prospect that this will worsen over time (24) due to increase in the volume of hemorrhage and surrounding edema, and on the observations that outcome is poorer following a rise in ICP (3), or radiological (30) or clinical worsening (21). Our results show that in contemporary practice such events are often awaited before a decision to operate is made.

Reasons for promoting a more conservative approach include the view that the merits of intervention within brain parenchyma itself are less clear (5), and that operative trauma may exacerbate damage. It is not possible from the design of this study to determine if all early operations were appropriate; nor, conversely, if those performed as a delayed procedure might have been more appropriate as an emergency, or perhaps even not at all. The lack of high quality evidence on which to base decisions upon has been noted.

A recent large, randomized prospective study in patients with a spontaneous intracerebral hematoma did not show a benefit from early surgery (20). However, the findings of the present study show that conservative approaches, as employed in the participating centers, was considered to have been unsuccessful in a substantial proportion of patients, leading to a delayed operation. Further research is needed to predict which patients may or may not be treated satisfactorily conservatively and which patients do or do not need early evacuation. Against the foregoing background, it is, perhaps, not surprising that there is even more uncertainty about the role of decompressive craniectomy. This operation does not aim to eliminate the source of brain damage, but, instead, to enhance the brain's capacity to cope with the effects of an expanding lesion or raised ICP. After reports in the 1970s indicated that the procedure was not often followed by recovery (6), it was little used for the next 2 decades. One of the reasons for this was a concern that a decompressive craniectomy by removing the counter pressure of the cranium could lead to worsening brain edema. This view has, however, not been substantiated by evidence in patients (25) and, more recently, there has been a resurgence of interest in the procedure. This is reflected in a substantial number of reports, many claiming some benefit from the procedure as recently reviewed by Hutchinson (16) and Pieck (25). Different approaches were used and the craniectomy was frequently combined with evacuation of the mass lesion (22). This was also the experience in

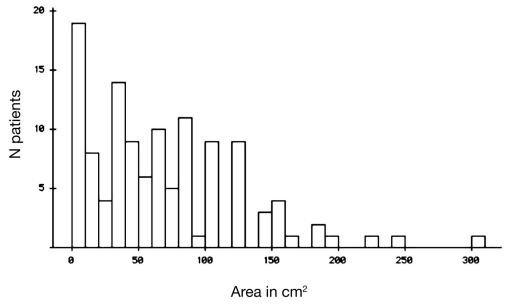

FIGURE 1. *Area of bone decompression as estimated by the intradural lesion study investigators in 119 cases of early surgery.*

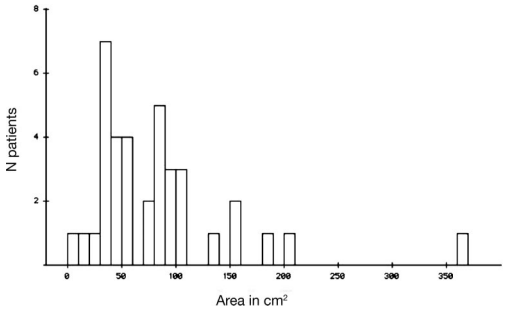

FIGURE 2. *Area of bone decompression as estimated by the intradural lesion study investigators in 37 cases of delayed surgery.*

our study and a decompressive craniectomy was used solely for control of raised ICP, without evacuation of a mass lesion, on nine occasions.

Comparisons based on cohorts treated at different times or different places have not provided clear directions. There is currently only one report of a randomized prospective comparison (31), but this study had many limitations. The procedure was limited to removal of only bone, without opening of the dura, and there is evidence (8, 32) that it is the latter step that is essential. In addition, the study was limited to children and, despite being performed over 7 years, only a small number were recruited.

Uncertainty may be compounded by lack of a standard technique for performing the procedure, in particular concerning its site and size. This is reflected in our finding of a wide variation in the dimensions of the craniectomies performed in this study. There is some evidence that a large decompression is needed for benefit (22, 25), and that a small one may even have adverse consequences (25). In many instances, particularly when associated with primary evacuation of a mass lesion, the dimensions were, in our opinion, too small (see *Figs. 1* and *2*). The picture obtained from the present survey is that decompressive craniectomy is currently performed usually as an adjunct to the evacuation of a mass lesion, when it is often limited to "leaving out the bone flap." Few patients were treated by deliberate decompressive craniectomy for the management of diffuse brain damage complicated by refractory, or raised intracranial pressure.

Despite the large number of patients that were studied, there are limitations in the potential to draw conclusions about relationships between the differing approaches to management and benefit in terms of outcome This reflects the variations in technique and timing of the procedure and it is evident that there was considerable bias in selection of patients for decompression. When carried out as part of an emergency operation, its use was strongly associated with evidence of more severe brain damage, as shown by the association between utilization of craniectomy and a lower GCS score and with loss of pupil reactivity (*Table 6*). In contrast, when employed as a delayed procedure, there was preferential use in younger patients. This probably reflects prevailing practice, and various articles have advocated that decompressive craniectomy should be done only to patients below 50 years of age (13, 22, 25). Clarification of the risks and benefits of decompressive craniectomy requires a prospective randomized trial.

CONCLUSIONS

Operative evacuation remains the primary method of management used by neurosurgeons in patients with a traumatic intradural lesion. Most operations are performed as an emergency when there is greater emphasis on the evacuation of extracerebral epidural and subdural hematoma. In more delayed surgery, the most frequent lesion evacuated was a brain contusion or laceration, and intracerebral hematoma. In almost half of such lesions that were treated by operation, this was performed only after a period of conservative management. Decompressive craniectomy was performed in a substantial proportion of patients, but the size of decompression was, in our opinion, too small in a substantial number of cases. The findings of the study point to the need for further research into the clinical management of patients with a traumatic intradural lesion. Evidence should be sought that will clarify which patients have a traumatic intradural lesion that can be managed satisfactorily conservatively and, conversely, those in whom "medical" management is inferior to surgical evacuation. Although the role of decompressive craniectomy is controversial, it is carried out in a substantial number of patients, either as a primary or delayed procedure. Evidence on which to base the use of this procedure is unlikely to be obtained unless prospective randomized comparative studies are performed.

APPENDIX

Collaborating Centers by country, hospital name, principal investigator (number of patients included):

Argentina (9): Hospital de Emergencias "Clemente Alvarez," Rosario (6): Carlos Rondina; Hospital Interzonal "Prof. Dr. Luis Guemes," Haedo (3): Pablo Schoon.

Australia (10): Royal Prince Alfred Hospital, Newtown (10): Michael Besser, Shirley Vallanc.

Belgium (8): University Hospital Gasthuisberg, Leuven (8): Jan Goffin.

Brazil (1): Hospital Santa Casa de Misericordia, Rio Grande do Sul (1): Carlos Alberto-Viera.

China (6): Prince of Wales Hospital, Hong Kong (6): Wai S. Poon.

Croatia (33): Rijeka University Hospital, Rijeka (6): Darko Ledic; Osijek University Hospital, Osijek (13): Bruno Splavski; University Hospital "Sestre Milosrdnice," Zagreb (14): Miroslav Vukic.

Denmark (6): Aarhus Kommunehospital, Aarhus (6): Carsten Kock-Jensen.

France (3): Hotel Dieu, Nantes (3): Roger Robert.

Germany (15): Virchow Klinikum, Berlin (8): Andy Unterberg; Der Universitat Leipzig, Leipzig (7): Jürgen Meixensberger, Matthias Jaeger.

Greece (19): Evangelismos Hospital, Athens (18): George Stranjalis; University Hospital of Heraklion, Heraklion (1): Constantine Katsanoulas.

Hungary (6): Medical Faculty of Pécs University, Pécs (6): Tom Doczi.

India (56): All India Institute of Medical Sciences, New Delhi (27): Veer Singh Mehta, Aditya Gupta; LTM Medical College & LTMG Hospital, Mumbai (29): Alok Sharma.

Italy (202): Ospedale Civile, Bolzano (31): Mario Vitale, Alex Alfieri; Ospedale Torrette Ancona, Ancona (4), Giovanni Bini; Ospedale San Raffaele, Milano (14): Luigi Beretta; Policlinico San Matteo, Pavia (11): Gianluigi Brambilla; Policlinico Universitario "G. Martino," Messina (18): Domenico D'Avella; Ospedale Niguarda, Milano (36): Anna Levati; Ospedale San

Gerardo, Monza (6): Giuseppe Citerio; Università di Brescia, Brescia (8): Patrizia Ghisi, Claudio Ferlinghetti; Università Cattolica del Sacro Cuore, Roma (6): Anselmo Caricato; Ospedale Maurizio Bufalini, Cesena (27): Giuliano Giuliani, Arturo Chieregato; Ospedale S. Maria dei Battuti, Treviso (4): Giuseppe Canova; Ospedale Borgo Trento, Verona (37): Luciano Cristofori.

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COMMENTS

First, a disclaimer: my institution entered eight patients into this study, but my colleagues and I were not involved in the data analysis or in the writing of the manuscript.

This paper provides a snapshot of the current state of the specialty in terms of management practices at many different institutions in many different countries. Such surveys are always interesting. However, such studies cannot help us sort out which centers are "right" and which ones are "wrong." As the authors point out, randomized studies are needed to answer some of the questions identified by this survey, but such studies are much easier to recommend than to perform.

Alex B. Valadka
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The authors present a comprehensive summary of the neurosurgical care of patients with traumatic intracranial mass lesions in Europe. This report is possible because of the hard work and dedication of a group of neurosurgeons who, for more than a decade, have organized the European Brain Injury Consortium (EBIC), developed a user-friendly, web-based survey instrument, and convinced a large number of European trauma centers to use it. As a result, they were able to obtain high-quality data on 729 patients with traumatic brain injury admitted to 67 hospitals in 24 different countries during a 3-month period. As a result, they could determine what is currently being done for this group of patients and correlate current practice with outcomes. The real value of their system will be in following trends and measuring the impact of new procedures or recommendations. For example, the value of decompressive craniectomy still is not clear. While their findings and those of others are provocative, only the study of a very large number of patients will be capable of answering this question, but the first step is organizing a large number of trauma centers and establishing a database that those trauma centers will consistently use. This report clearly demonstrates that EBIC has successfully accomplished this goal. Unfortunately, such collaboration or survey instruments currently do not exist in the United States.

Donald W. Marion
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We are provided with another excellent epidemiologic and descriptive survey of current issues in traumatic brain injury, in this case, surgical management, by the EBIC. Almost two-thirds of patients managed in these primarily European centers underwent surgery for evacuation of a mass lesion and/or decompressive craniectomy, which is described by the authors as representative of current neurosurgical practice.

Indeed, data from the United States would suggest otherwise. Information from the American College of Surgeons trauma center verification/consultation program would indicate that surgical intervention (excepting intracranial pressure monitors) is considerably lower than what has been observed in Europe. Less than 5% of centers in the United States (from a database of more than 200 centers) perform more than 25 emergency craniotomies for trauma each year and more than 50% perform less than 10 procedures per year. Perhaps we are just not as surgically aggressive as our EBIC colleagues; however, the only inclusion criterion in the present survey was based on radiologic signs "as determined by the principal investigators," irrespective of Glasgow Coma Scale.

It is very important for the reader to recognize that this study was a practice survey. While there was uniform data collection, there was no centralized reading of the computed tomography scans, there was no uniform surgical approach, especially as relates it to decompressive craniectomy, and there was no reliable information on outcome.

So long as we understand that the information from this survey simply reflects the surgical practice patterns, primarily in Europe, then perhaps this information can be used to our advantage in designing the necessary surgical trials to attempt to answer the many questions the authors have raised.

Jack E. Wilberger
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The main objective of the current study is to survey the contemporary management of head injury patients with a space occupying intradural lesion by taking advantage of the facilities provided by the EBIC. The authors may also expect to draw guidelines on the indications for emergency surgical evacuation. Unfortunately, this has not been the case. Data obtained from 67 centers in 24 countries is the source of this study. The indications and outcome of decompressive surgery were cross-examined in a cohort of 729 head injuries, in a prospective fashion, over a period of three months. Patients were included in the study based only on radiological evidence of an intradural mass lesion, disregarding their initial Glasgow Coma score (half of them were classified as severe, one-fifth as moderate, and another fifth as mild head injuries). More than 500 of the patients

underwent surgery (two-thirds of them as an emergency procedure and another third either as a delayed procedure or both). A 22% mortality was reported for the group undergoing surgery as compared to 20% in the non-surgically treated group. Mortality in the surgical group was higher in those undergoing emergency surgery (31%) as compared with those undergoing delayed surgery (21%), and within the first group, it was higher in the subgroup undergoing a decompressive craniotomy or craniectomy.

While the study was prospectively conducted in a contemporary set of patients using state-of-the-art facilities, both in terms of imaging and care, so far, the treatment provided does not differ much from what was at use in the third-quarter of the last century. At the time, a shift in the midline echo was a mandatory indication for at least burr holes in severe or deteriorating head injuries. In the same way, 93% of subdural hematomas in the current study, were surgically treated. But, yesterday, as today, we still lack precise evidence-based indications.

The study highlights this lack of homogeneity and guidelines for proper decision-making in the management of moderate to severe head injuries with an intradural mass lesion. Even more, when the decision to proceed with surgical treatment was based on the presence of a deteriorating patient, the so-called decompressive procedure differed in size and site from one center to another, making it difficult to ascertain its value. Outcome was restricted to mortality but nothing is said about morbidity within the survival group. I miss this information to complete the picture on the possible indications and benefits of decompressive craniotomy/craniectomy.

The authors stress the need to conduct prospective randomized trials as an urgent priority to define proper guidelines in the management of head-injury patients. I could not agree more.

Jose G. Martin-Rodriguez
Madrid, Spain

Detail from Norwegians Landing on Iceland, in the Year 872 (oil on canvas, 1877) by Norwegian artist Oscar Wergeland. (Courtesy of National Gallery, Oslo).