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Anterior Cervical Fusion and Osteosynthetic Stabilization According to Caspar: A Prospective Study of 41 Patients with Fractures and/or Dislocations of the Cervical Spine

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Between June 1984 and April 1988, 41 patients with severe posttraumatic lesions of the cervical spine between the C2-C3 and the C7-T1 level seen consecutively were treated by an anterior cervical fusion and osteosynthetic stabilization according to Caspar. These patients were prospectively studied. Seven patients had a bilateral facet dislocation, 5 a unilateral facet dislocation, 9 an anterior subluxation, 9 an anterior compression fracture, 5 a hangman's fracture, and 6 a hyperextension injury at a lower cervical level. From a neurological point of view, there were 12 patients with an initial complete transverse lesion and 14 with an incomplete transverse lesion, and the remaining 15 patients did not have any deficit initially. Four patients died during the first 3 months after the operation. In 38 patients good anatomical position was obtained, generally by the intraoperative use of the vertebral distractor of Caspar. In all patients excellent immediate postoperative stability of the spine was obtained, although in 2 patients a second operation was necessary a few days after the first one. Postoperatively all patients were "immobilized" by a soft collar for 3 months. Four patients with an initial complete transverse lesion showed some neurological recovery in the postoperative period, and all patients with an incomplete transverse lesion improved. There were no postoperative neurological disturbances in the group of patients who were neurologically normal from the beginning. The mean postoperative hospitalization time was 13.6 days. These results were compared to the results from the literature, concerning other conservative and operative treatments for posttraumatic lesions of the cervical spine. (*Neurosurgery* 25:865-871, 1989)

Key words: Instrumentation, Spinal cord injury, Spinal fusion, Surgical technique.

INTRODUCTION

Operations on the cervical spine by an anterior approach have been performed since the 1950s as reported by authors such as Bailey and Badgley (1), Dereymaeker and Mulier (11), Southwick and Robinson (25, 28), and Cloward (9). Ventral cervical fusion techniques have been carried out for more than 20 years, particularly for cervical body tumors and unstable cervical fractures and subluxations (10, 32). From a theoretical point of view the anterior approach to the cervical spine offers many advantages in comparison with the posterior approach: the anterior approach is simple and less traumatizing and can be performed on a patient in a normal dorsal decubitus position, with a skull traction device in place; this anterior approach permits partial or complete resection of a pathological vertebral body and an interbody stabilization which resembles the situation of a congenital block vertebra.

Anterior plating techniques for the cervical spine have not been universally accepted: the available osteosynthetic plates were probably not ideally adapted to the cervical spine and the instruments for dissection and fixation of the cervical spine were not optimal. So for many authors the operative risks were too great.

The new instrumentation devised by Caspar (5-7) has been developed to improve these shortcomings, standardizing the anterior operative procedures for the cervical spine and making them safe.

In the neurosurgical department of the University of Leuven a series of 41 patients with severe posttraumatic cervical spine injuries seen consecutively have been treated by cervical interbody fusion and supplementary osteosynthetic plate fixation according to Caspar between June 1984 and April 1988 (15). The lesions were situated between the C2-C3 and the C7-T1 levels.

TECHNIQUE AND METHODS

As already mentioned (30), the most important technical advantages of the Caspar procedure are: the vertebral body distractor, the trapezial osteosynthetic plates, and the special burr holder.

The vertebral body distractor allows parallel spreading and good visibility into the intervertebral space. Relatively great distraction forces can eventually be applied by this instrument to realign posttraumatically displaced vertebral bodies. An intercorporeal graft of the Smith-Robinson type can be introduced under compression, which favors firm bony fusion. The trapezial osteosynthetic plates enable the surgeon to introduce the fixation screws at the right vertical plane into the vertebral bodies, while the plate itself is secured by its shape against vertical shifts at the anterior border of the spine. The singular and double drill guides have a security system which enables a safe drilling and positioning of the fixation screws with their deepest points just at the level of the posterior cortex of the vertebral bodies, so the stability of the fusion is favored.

As already mentioned, 41 patients have been treated over a period of 4 years for posttraumatic injuries of the cervical spine by this anterior cervical fusion and osteosynthetic stabilization technique according to Caspar. This series included 34 men and 7 women with an age distribution as presented in Figure 1: 60% of the patients were younger than 30 years.

From a biomechanical and morphological point of view the patients were classified according to Cheshire (8): 7 patients had a bilateral facet dislocation, 5 a unilateral facet dislocation, 9 an anterior subluxation, 9 a vertebral body compression fracture, 5 a hangman's fracture, and 6 a hyperextension injury at a lower cervical level.

From a neurological and functional point of view the

FIG. 1. Age distribution of the 41 patients.

patients were categorized at the moment of their arrival in our hospital according to Frankel et al. (14): Class A patients have a complete transverse spinal cord lesion (this group included 12 patients); Class B patients have a complete motor deficit but maintain some degree of sensibility (there were no patients with these characteristics in our series); Class C patients show some motor activity, but functionally without any importance (5 patients); Class D patients have functionally useful but not normal motor activity (9 patients); Class E patients have normal sensibility and motor activity (15 patients). In other words, 12 patients had a complete transverse lesion, 14 patients an incomplete lesion, and 15 patients had no neurological disturbances.

Thirty-seven patients were initially treated by skull traction; this procedure was followed after some days by the operation according to Caspar. Reduction of displaced vertebral bodies was achieved by skull traction, external manipulation, and the use of the vertebral distractor of Caspar during the operation, or by a combination of these methods.

The distribution of all stabilized segments is presented in Figure 2; several patients were operated on at more than 1 level. The segment C5-C6 was most frequently involved. An incomplete vertebral body resection was performed 6 times. A complete vertebral body was resected on 5 occasions.

The follow-up period for the 41 patients is presented in Figure 3.

Table 1 gives a survey of all patients. As examples, some specific cases are presented in Figures 4, 5, 6, 7, and 8.

RESULTS

Mortality

Four of the 41 patients died during the first 3 months after the operation: 3 of these patients had a complete transverse lesion, and the 4th patient had been afflicted previously with Steinert disease. All deaths occurred as the result of a sudden cardiac arrest (23). The global mortality in this series was 9.7%, with a mortality of 25% for the group of patients with a complete transverse lesion.

Anatomical results

In 38 of the 41 patients an anatomically good position was achieved, and this was accomplished 31 times by the use of the vertebral body distractor of Caspar. On 7 occasions, preoperatively applied skull traction and/or external manipulation sufficed for good reduction. In the case of 1 patient with a bilateral facet dislocation and of 2 others with unilateral facet dislocation, the combination of external manipulation and the vertebral body distractor allowed only an incomplete

FIG. 2. Distribution of all stabilized segments (41 patients); some patients were treated by fusion of more than 1 segment because of the extension of the traumatic lesion or because of the coexistence of another degenerative lesion at a neighboring segment.

FIG. 3. Duration of follow-up.

reduction. In the first patient this was due to a coexisting fracture of a pedicle, in the second and third patients to the long time interval between trauma and reduction and the presence of a fracture of the facet joint.

In all patients excellent immediate postoperative stability of the cervical spine was obtained, although in 2 patients this required a second operation some days after the first one. Indeed, in 2 patients with complete interruption of all stabilizing ligamentous structures, the first operation resulted in some overdistraction of the fused segment, which was followed by a loosening of the osteosynthetic plate and screws and renewed anterior subluxation. Postoperatively all patients were treated with the use of a soft collar for 3 months.

Neurological and functional results

The final neurological and functional results in relation to the situation at admission are presented in Figure 9. Four of the 12 patients with an initial complete transverse lesion recovered, 2 to Class C and 2 to Class D according to Frankel et al. (14). All patients with incomplete transverse lesions improved, the 5 patients of Class C to Class D, and 8 of the 9 patients of Class D to Class E. The last patient in Class D had improvement in motor activity but some slight neurological disturbances were preserved, so he stayed categorized in Class D. Finally, all patients without any neurological deficit at admission were also neurologically normal after the operation.

Apart from 8 patients who were transferred to our department long after their original trauma, the mean preoperative

TABLE I
Summary of Cases

Morphological Classification	Patient Age (yr) and Sex	Levels Fused ^a	Neurological Situation at Admission (Frankel Score)	Final Neurological Result (Frankel Score)
Bilateral facet dislocation	21 M	C2-C3	A	D
	23 M	C5-C6	E	E
	23 F	C6-C7 (C7-T1)	A	A
	47 M	C5-C6	A	A (died)
	53 M	C5-C6	A	A (died)
	75 M	C4-C5	A	A
	80 M	C6-C7 (C7-T1)	C	D
Unilateral facet dislocation	23 M	C6-C7	D	E
	24 M	C4-C5	A	A
	31 M	C3-C4	E	E
	36 M	C6-C7	D	E
	41 M	C6-C7	D	E
Anterior subluxation	15 M	C4-C5	E	E
	19 F	C2-C3 C3-C4	E	E
	21 M	C3-C4 (C4-C5)	C	D
	22 M	C5-C6	E	E
	24 M	C4-C5	D	D
	24 M	C3-C4	C	D
	32 F	C6-C7	E	E
	34 M	C5-C6	D	E
	44 M	C5-C6	C	D
Compression fracture of vertebral body	14 M	C4-C5 (P) C5-C6	E	E
	14 M	C6-C7 (C) C7-T1 (C5-C6)	C	D
	19 M	C6-C7 (C) C7-T1	A	A
	20 M	C5-C6 (C) C6-C7	A	C
	22 M	C4-C5 (C) C5-C6	A	C
	23 M	C4-C5 (P) C5-C6	E	E
	24 M	C4-C5 (P) C5-C6	E	E
	30 M	C6-C7 (C) C7-T1	D	E
	48 M	C4-C5 (P) C5-C6	E	E
Hangman's fracture	23 M	C2-C3	E	E
	23 M	C2-C3	E	E
	28 F	C2-C3	E	E
	28 F	C2-C3	D	E
	56 F	C2-C3	E	E (died)
Hyperextension lesion at lower cervical level	18 M	C6-C7 (C5-C6)	A	C
	22 M	C3-C4	E	E
	31 M	C3-C4	D	E
	51 M	C6-C7 (C5-C6)	D	E
	64 M	C3-C4 C4-C5	A	A (died)
	69 F	C5-C6	A	A

^a (P), partial corpectomy; (C), complete corpectomy. Parentheses indicates levels that were fused because of less important lesions, generally of a degenerative nature.

FIG. 4. A 23-year-old man who suffered a gymnastics accident. Frankel Class E. *A*, status at admission with bilateral facet dislocation C5-C6. *B*, status 1 week postoperatively: lateral. *C*, status 1 week postoperatively: anteroposterior. *D*, status 8 months postoperatively: firm bony fusion.

time of skull traction was 5.3 days. The mean postoperative hospitalization time was 13.6 days.

DISCUSSION

The fact that nowadays so many different conservative and operative procedures are used for the treatment of cervical spine and spinal cord injuries reflects the lack of a clearly superior technique. Bucy stated in a recent editorial note in the journal *Surgical Neurology* that "We recognize that the treatment of cervical spine fractures and dislocations is not yet established and therefore feel that any well-considered procedure deserves consideration" (4).

To our knowledge, this study of the Caspar technique is the first one of such magnitude in the English literature. The study by Tippets and Apfelbaum (30) concerns 19 posttraumatic cases with a mean postoperative follow-up of 4.9 months.

The results obtained in our study, were compared with the known results from the literature concerning other conservative and operative treatments.

As already mentioned, we were confronted with an overall postoperative mortality of about 10% and a mortality of 25% for the group of patients with complete transverse lesions.

FIG. 5. A 23-year old man who suffered a traffic accident. Frankel Class D. *A*, status at admission: unilateral facet dislocation C6-C7. *B*, computed tomographic scan at admission: confirmation of the facet dislocation C6-C7 on the right. *C*, status 5 months postoperatively.

FIG. 6. A 15-year-old male patient who suffered a gymnastics accident. Frankel Class E. *A*, status at admission: anterior subluxation C4-C5 in spite of 8 months conservative treatment (including 3 months with a halo brace) at another hospital. *B*, status 3 months after the operation.

FIG. 7. A 24-year-old man who suffered a traffic accident. Frankel Class E. *A*, status at admission with anterior compression fracture C5 and kyphotic angulation of the spine at C5-C6. *B*, status 3 weeks after partial cervical body removal and fusion with a C-shaped iliac crest graft.

FIG. 8. A 20-year-old man who was injured by a heavy weight striking his head. Frankel Class A. *A*, status at admission: severe compression fracture C6. *B*, CT with reconstruction image at admission. *C*, status 2 months postoperatively. This patient was referred to a rehabilitation center. Recuperation to Frankel Class C.

FINAL RESULT

		A	B	C	D	E
FRANKEL SCORE AT ADMISSION	A	8		2	2	
	B					
	C				5	
	D				1	8
	E					15

FIG. 9. Final neurological results in relation to the neurological situation at admission [classification according to Frankel et al. (14)]

Bohlman (2) observed in his series of 229 patients a mortality of 46% for the complete transverse lesion group and a mortality of 18% for the incomplete transverse lesion group. Kiwerski et al. (19) noted in their series of 1000 patients an overall mortality of 16.7% and a mortality of 33% for the group with complete lesions. These results were confirmed in the studies of Reynier et al. (24), Senegas et al. (27), and Ducker et al. (13). Considering the postoperative mortality in these studies our personal results were at least as good.

We obtained excellent realignment of the cervical spine in 93% of our 41 patients, generally by the intraoperative use of the vertebral distractor of Caspar, which allowed high local distraction forces. In comparison, Bombart et al. (3), using only traction and external manipulation techniques, obtained a good reduction in 80% of their 87 patients.

Apart from 2 patients who needed a second stabilizing operation, excellent stability of the cervical spine was obtained in all patients immediately after the operative procedure. For both of the above-mentioned patients the stability was also optimal immediately after the second operation. The number of patients with final good stability of the cervical spine after pure conservative treatment differs from one author to the other: Bohlman (2) noted a chronic instability in 42% of his 78 conservatively treated patients. Cheshire (8), on the other hand, found late instability in only 5.4% of his 212 patients, although the instability rate was 21% for the subgroup of patients with anterior subluxations. For operative procedures the number of patients with final optimal stability is also subject to greater differences in the literature. Verbiest (33) studied 78 patients treated by an anterior fusion with a tibia graft and without osteosynthetic plate fixation: all patients showed firm bony fusion with a postoperative kyphotic position of the spine in only 5.1% of the patients. Nevertheless, all of these patients were immobilized postoperatively by bedrest for 6 weeks, followed by an immobilization with a Somi brace for another 6 weeks. On the other hand, Kewalrami and Riggins (18) studied 44 patients with anterior fusion without osteosynthetic plate fixation and found significant fusion problems in 50% of their patients. In the opinion of many authors an anterior fusion is indicated only in patients with a compression fracture of a vertebral body and is contraindicated in patients with posterior instability, such as anterior subluxations and facet dislocations; the operative procedure in these cases would compromise the only remaining stability (22, 29, 31). A posterior approach would offer

more guarantees for final stability: Roy-Camille (26) found, for posterior osteosynthesis operations in cases of primary posterior instability, a final instability in 20% of his patients. However, the preoperative differential diagnosis between a simple compression fracture with intact posterior ligaments and a compression fracture with ruptured ligaments is often very difficult (8). Furthermore, in our series of patients with posterior instability treated by the anterior technique of Caspar and a follow-up period of at least 6 months, there was no patient with final postoperative instability.

The neurological results in our 12 patients with an initial complete transverse lesion were equal to the best results for other conservative and operation techniques (12, 14, 16, 27). For the group of patients with incomplete transverse lesions the neurological and functional results were excellent in comparison with the results from other studies (14, 16, 17, 21, 27): all patients in our series were able to walk in contrast to the generally reported figure of 83 to 96% of the similar patients in the other reports. Since the operation of Caspar allows fast and good reposition and stability of the cervical spine, the best condition is created, in our opinion, for a possible recovery of the neurological disturbances. In the case of insufficient stability, however, such as in patients treated by skull traction or even by a halo brace (20), the already damaged spinal cord is subject to repeated microtrauma, which could compromise eventual neurological improvement.

Finally, comfort for the patient is served by this technique; the duration of treatment is reduced to a minimum, and there are no major postoperative subjective complaints.

Taking into account these anatomical and functional results, we feel that this newly developed technique according to Caspar is a step forward in the posttraumatic treatment of the cervical spine and spinal cord.

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COMMENT

Drs. Goffin, Plets, and Van den Bergh should be complimented on their excellent prospective study of the use of Caspar instrumentation for anterior cervical fusion and frac-

tures/dislocations of the cervical spine. Their results are both clinically and radiologically excellent. Their lack of complications, failure of fusion, and bony deformity is remarkable. A second operation required on 2 of the patients was said to be due to overdistracted and not due to the screws' backing out, caused by not seating the screws all the way to the posterior cortical margins of the body, which Caspar states as the leading cause of screw loosening.

This is an excellent series, using a new form of instrumentation which has been added to the neurosurgeon's armamentarium for treatment of fractures and dislocations of the cervical spine. It will be hard to match or beat these results.

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