

One-stage surgical treatment of cervical spine fracture-dislocation in patients with ankylosing spondylitis via the combined anterior–posterior approach

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Abstract

The aim of the article is to investigate the efficacy and safety of 1-stage surgical therapy via combined anterior–posterior approach on cervical spine fracture in patients with ankylosing spondylitis (AS).

We retrospectively analyzed profiles of 12 AS patients with severe fracture-dislocation of cervical spine received 1-stage combined anterior–posterior surgery in our hospital from October, 2013, to October, 2015, including clinical characteristics, follow-up data, and imaging records. We compared the parameters before and after surgery on the basis of neurological function, bone fusion, Cobb angles of operation segment, Barthel index (BI) score, and incidence rate of complications.

A total of 12 patients received 1-stage surgery via combined anterior–posterior approach within 3 days after injury. No severe complications and death occurred. All patients received the successfully anatomical reduction of fracture-dislocation, in which 9 achieved function restoration. The latest follow-up showed the neurological function status of patients was improved. The Cobb angles of operation segments were recovered; the rate of bone fusion was 66.7% at 3 months and 100% at 6 months post-operation. The BI score was improved, 4 cases of moderate dependence and 8 of slight dependence at the latest follow-up compared to 10 of severe dependence and 2 of moderate dependence preoperation. In no cases did severe complications from implanted instrumentation occur.

It was high efficacy and safety that the surgical therapy was performed on cervical fracture-dislocation in AS patients by the 1-stage combined anterior–posterior approach. The key of the surgery is the robust stabilization and full decompression of fracture spine at early stage. In addition, if spinal anatomical reduction of fracture segments is difficult to be achieved, the functional restoration should be adopted during the surgery.

Abbreviations: AS = ankylosing spondylitis, BI = Barthel index.

Keywords: ankylosing spondylitis, cervical spine fracture, combined anterior–posterior approach, full decompression, robust fixation

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AH, DX, and XC equally contributed to this study.

Declarations

Ethics Approval and Consent to Participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and supporting materials: All data are available, and there is no supporting material in this study.

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1. Introduction

Ankylosing spondylitis (AS) is a chronic, systematic, and inflammatory autoimmune arthritis.^[1] AS has an estimated prevalence of about 0.05% to 1.4% in the population worldwide. It most often strikes the people between 20 and 30 years of age while first occurs in children and older adults age from 13 to 31 years old.^[2] It is 3 times more common in men than in women.^[1]

AS primarily affects the spine and the sacroiliac joints featuring by spine fusion, deformity, and osteoporosis.^[3,4] The repeatedly chronic inflammation in intervertebral discs, ligaments, tendons, joint capsule and paraspinal tissue of AS patients commonly results in extensive ossification of these tissues, spinal fusion, and increased bony rigidity and brittle.^[3–6] As for the patients with a long-term AS history, the severe kyphosis often occurs due to the widespread osteoporosis and the push of self-body gravity.^[5,6] As a consequence, the severe osteoporosis, kyphosis, progressive bony fusion, rigidity and brittle in spine predispose to spinal fractures, sometimes accompanied by spinal cord injury. Therefore, the AS patients with spinal kyphosis often need to use the front bending position, resulting in rigid cervical extension.

The cervical spine, especially at C5–7, is the most prone to fracture of the place of AS patients, accounting for 54 to 73% of all AS spinal fractures.^[7–9] Even slight force can lead to unstable cervical fracture-dislocation with neurological lesion.^[7,8] It is

estimated that the mortality of such kinds of patients ranges from 6.6 to 26.3%.^[8–10] When the symptom of cervical spine instability and neurological impairments is observed in these patients, surgery is highly regarded as the efficient treatment method for these patients.^[14,15]

Although it is very challenging for the satisfactory therapy of cervical spine fracture-dislocation because of extensive osteoporosis, high cervical instability and neurological injury in AS patients, surgery is still considered as the most effective technique for these patients.^[11–13] The common surgical approaches for cervical spine fracture mainly include simple anterior approach alone, posterior approach alone, and combined anterior–posterior approach.^[14,15] Due to the extensive osteoporosis in spine of AS patients, it is very challenging for the surgery to avoid the second injury of spinal cord and the severe complications no matter which surgical approach adopted.^[11–16] Generally, cervical fracture appears to be unstable Chance fracture, often affecting anterior, middle, and posterior column (3-column) with high probability of dislocation, neurological impairment. The surgery by simple anterior approach only fixes anterior and middle column, which cannot resist the posterior column tension. So, implanted crew or plate becomes the focus of stress force. Consequently, the instrumental complications, such as screw loosening, breaking and migration, occur very often after simple anterior surgery, possibly further resulting in esophagus leakage.^[12,16,19] It was reported that the decompression and fixation by posterior approach alone is better than the simple anterior approach in the context of severe instability of cervical spine fracture.^[17,18] And some reports showed that the internal fixation by modified posterior approach plus instrument wearing improved the efficacy of the cervical fracture treatment.^[19,20] However, the cervical spine fixation by the posterior approach alone is still incompetent, and the risk of complications, including the pop-out of anterior column fusion, pseudo-joint formation, is high.^[21]

Recently, the combined anterior–posterior method has drawn attention gradually because the surgery by this method is able to achieve 3-column fixation and fusion. It still remains controversial in which method is the safest and most effective due to the high risk of complications after surgery.^[14,15]

However, there is no such application reported due to the limited incidence of AS patients with cervical fractures so far. Here, we reviewed the profile of 12 AS cases with severe fracture-dislocation of cervical spine received 1-stage surgery via the combined anterior–posterior approach within our hospital from October 2013 until October 2015, and presented our therapeutic management experiences in this study.

2. Material and method

2.1. General data

The review of patient profile was approved by our hospital ethics committee.

The case collection criteria were shown in Figure 1. Patients diagnosed as AS with cervical fracture accompanied with or without spinal cord injury, injured by trauma (car accident, falling, and so on), received 1-stage surgery via the combined anterior–posterior approach, and registered well with exhaustive medical records, were included in this study. The AS patients with cervical fracture who received other surgical treatment except the combined anterior–posterior approach or who has other fractures were excluded. Total 12 AS patients with cervical

spine fracture-dislocation who received surgical treatment by the combined anterior–posterior approach in our hospital from October 2013 until October 2015 were included in this study, and 5 cases were excluded. The general data of patients were shown in Table 1. Of this 12 cases, 9 are men and 2 women; mean age, 55.0 ± 6.6 years (range, 44–66 years); mean AS duration, 27.3 ± 5.1 (range, 18–35 years); median follow-up, 25.3 ± 6.6 months (range, 12–36 months); all patients underwent standard (anteroposterior and lateral) cervical and thoracic radiography, and computed tomography (CT) and magnetic resonance imaging (MRI) of the spine. All patients were diagnosed with cervical spine fracture-dislocation. The displaced distance of fractured bone was measured accurately by x-ray. The cervical injury of 7 patients was caused by minor car accident; 4 by falling down from bicycle and 1 by stick hitting. The spinal cord injury was assessed according to Frankel Grade classification, 2 cases in Grade A, 3 in Grade B, 5 in Grade C, and 2 in Grade D. The fracture occurred at C5, C6, and C7 the vertebral body and C5/6, C6/7 disc.

2.2. Operative technique

All patients received the skull traction for 24 to 72 hours. The conservational skull traction in line with spine curve was applied to all patients to reduce dislocation or fracture dislocation, during which each patient was monitored closely in case of the secondary spine injury. For patient transfer, cervical spinal immobilization must be performed with the supervision by the experienced and skilled spine surgeon. To decrease the risk of cervical dislocation deterioration by tracheal-intubation, the tracheal-intubation was applied to all patients with the full monitoring and local anesthesia by fiberoptic bronchoscope.

Under general anaesthesia, manual reduction was performed with fluoroscopic guidance. The limb weakness and numbness symptoms in patients were monitored during the tracheal-intubation. After the fracture reduction, the patient's neck was lifted in line with the relative cervical curve before injury. The fracture disc and cartilage endplate were removed for spinal cord decompression. If anatomical reduction is difficult to be achieved due to the facet joint locking, the spine should be fixed at the best functional position. At least 2 segments above and below the fracture site, should be fixed by 2 pair of mass screws through the anterior approach, respectively.

After anterior operation, the patients need to take prone position for posterior surgery, which leads kyphosis lift off the bed. So the chest and abdomen need to pad up to the original convex angle during surgery for the posterior approach. The posterior approach was adopted to remove the detached bone fragments of vertebral lamina, unlock and fix the small locking joints by lateral mass screw. The range of cervical posterior fixation, including the injury segment up and down 1–2 segments, was decided according to the evaluation of the patient's heart and lung function, operation time, and intraoperative bleeding.

2.3. Patient follow-up

One day post-operation, the patient was allowed to walk with a Philadelphia collar. Philadelphia collar was used for 3 months. Follow-up was carried out at 3, 6, 12, 24, and 36 months post-operation. All patient received x-ray of cervical spine, or CT or MRI if it was required. Frankel scale was used to evaluate the neurological status pre- and postoperation. Bony fusion rate and Cobb angles of operation segments were used for the assessment

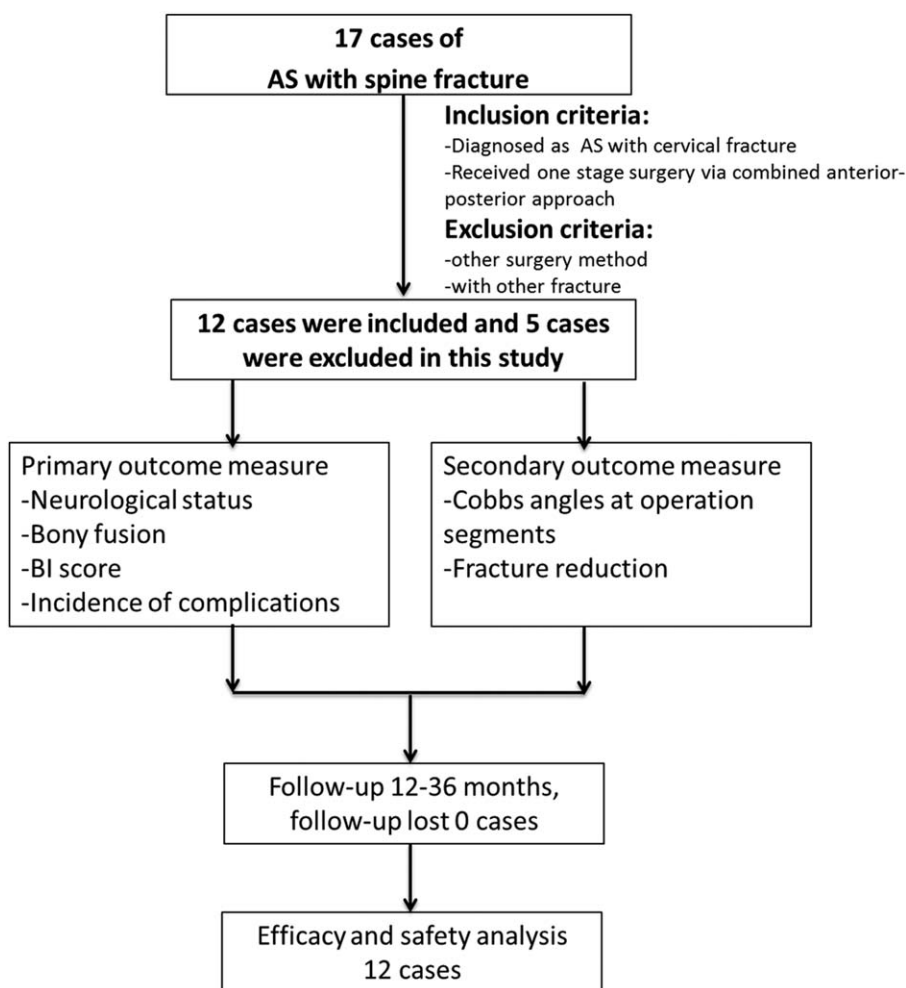


Figure 1. Flow chart of this study.

of the status of fracture recovery. The Barthel index was adapted to measure of neurological deficit, $60 < BI \leq 99$ for slight dependency, $40 < BI \leq 60$ for moderate dependency and $BI \leq 40$ severe dependency. The incidence of complications resulted from implanted instrumentation, for example, screw loosening and

breaking, fusion cage subsidence, titanium rod breakage, was used to evaluate the cervical fixation status. It was viewed as spine reduction failure if the distance between 2 surgery-restored vertebral bodies was more than 3 mm; and reduction success if 1–3 mm; anatomical reduction if less than 1 mm.

Table 1

General data of 12 AS patients with cervical spine fracture-dislocation.

Patient No.	Sex	Age, year	Follow-up, month	AS duration, year	Trauma	Fracture site	Surgery duration, min	Blood loss, mL	Fracture segment migration distance before surgery, mm	Fracture segment migration distance after surgery, mm	Timing of surgery (after injury), days
1	M	52	28	30	Minor car accident	C6–C7	245	280	2	1	2
2	M	55	24	30	Minor car accident	C5	256	350	4	2	1
3	M	48	18	20	Minor car accident	C5–C6	220	400	3	2	2
4	F	61	12	33	Minor car accident	C5–C6	275	400	2	0	2
5	M	66	36	30	Minor car accident	C7	280	300	3	1	3
6	F	57	32	26	Minor car accident	C6–C7	300	450	1	0	3
7	M	51	26	26	Falling	C7	275	380	5	2	3
8	F	55	20	28	Falling	C6	300	420	3	2	2
9	F	44	22	18	Minor car accident	C6	245	440	3	1	2
10	M	49	30	22	Falling	C5–C6	255	300	2	1	1
11	M	59	30	29	Stick hitting	C5	210	330	2	1	2
12	M	63	26	35	Falling	C6–7	240	350	1	0	2

Table 2**The surgical results and medical imaging data of 12 AS patients with cervical spine fracture-dislocation.**

Patient No.	Frankel Grade		Fusion time (m)		Complications caused by instrumentation			Cobb angle of surgical segments (°)			BI score	
	Before surgery	Last follow-up	Screw loosening	Fusion cage subsidence	Titanium rod breakage	3 months post operation	Last follow-up	Before surgery	3 months post operation	Last follow-up		
1	C	E	3	0	0	8.6	8.2	0	50	80		
2	A	C	3	0	0	5.4	5.4	0	35	45		
3	B	C	3	0	0	12.3	12.5	0	45	50		
4	B	D	3	0	0	7.7	7.5	0	50	60		
5	C	D	6	0	0	6.7	7.0	0	55	70		
6	C	D	6	0	0	14.5	14.8	0	50	65		
7	A	D	3	0	0	10.2	9.9	0	40	60		
8	C	D	6	0	0	8.1	8.0	0	50	65		
9	C	D	6	0	0	6.0	5.5	0	60	65		
10	B	E	3	0	0	5.5	5.9	0	65	75		
11	D	E	3	0	0	9.3	9.0	50	70	80		
12	D	E	3	0	0	8.7	9.0	60	75	85		

2.4. Statistics

SPSS 18.0 software was used for statistical analysis. Frankel grade, bony fusion, and instrumentation complication were interpreted by percentage and statistically analyzed by the Chi-square test. Cobb angle and BI score were expressed by mean ($X \pm S$) and analyzed by *t* test. $P < .05$ was viewed as statistical significance.

3. Results

All patients were surgically treated via 1-stage combined anterior–posterior approach at early stage (Table 2 and Fig. 1). The median operation duration was 258.4 ± 28.6 minutes, and bleeding volume in surgery was 366.7 ± 57.1 mL. The patients with severe complication, including cardiac arrest, heart failure, and respiratory failure were not found. No death case occurred within perioperative and follow-up stage. All 12 AS patients with severe fracture-dislocation of cervical spine received the 1-stage surgery via combined anterior–posterior approach within 3 days after injury. All patients got successful fracture reduction. Of 12 cases, 3 of patients achieved anatomical reduction (25%), 9 achieved function restoration (75%). In no cases did neurological deterioration occur. The neurological lesion of all cases was recovered to different degrees, 2 in Grade C, 6 in grade D, and 4 in grade E by Frankel Grade classification, and there is significant difference between post- and preoperation ($P < .0001$, Table 3). The BI score was improved, 4 cases of moderate dependence and 8 of slight dependence at the latest

follow-up compared to 10 of severe dependence and 2 of moderate dependence before operation ($P < .0001$, Table 3). The Cobb angles of operation segments at a final follow-up were no significantly difference compared to that at 3 months post-operation ($P = .790$); the rate of spine bony fusion was 66.7% after 3 months postoperation and 100% after 6 months postoperation ($P < .0001$, Table 3). Meanwhile, the obvious complications caused by instrumentation, such as screw loosening and breaking, fusion cage subsidence, titanium rod breakage, were not observed in all patients in this study.

4. Discussion

Recently, the combined anterior–posterior method has been adopted gradually because the surgery by this method is able to achieve 3-column fixation and fusion.^[11,14–16,19] But, the patients with heart or respiratory failure cannot afford the long surgery duration, severe surgical injury and high blood loss, high risk of perioperative period complications, this combined anterior–posterior method is not suitable for them.^[11,14–16,18–22]

In this study, our data proposed that the combined anterior–posterior approach could be the optimal solution for the therapy of cervical spine fracture in AS patients. The usage of this method is easier to achieve the complete spinal decompression, robust fixation of anterior, middle and posterior vertebrae column, and rapid alleviation of neurological impairment. Furthermore, the surgery via this combined approach could overcome the weakness of simple anterior method or simple posterior method. After rigorous stabilization of cervical spine fracture, the fusion rate of 3-column was increased at early stage; in contrast, the incidence of loosening, detachment, breaking and fusion cage subsidence of implanted instrumentation was decreased. Due to the robust fixation, the patients were able to maintain better intensity of the cervical activity and get out of bed earlier, which helped to decrease the complication occurrence of hypostatic pneumonia, deep venous thrombosis and bedsores. To achieve the vigorous internal stabilization in our cases, the cervical spine reconstruction was performed firstly by fixing at least 2 segments above and below the fracture site, including the injury segment. Then, the range of cervical posterior fixation, including the injury segment up and down 1–2 segments was confined. In this study, the Cobb angles of all patients at the final follow-up were found no significant difference from that after surgery, and the bony

Table 3**Statistical analysis of the evaluation on the surgical outcome of patients.**

Assessment of time point	Frankel Grade	Fracture dislocation (mm)	Surgical segment Cobb angle (°)	BI score
Preoperation	2.6 ± 1.0	2.6 ± 1.2	–	–
Postoperation	–	1.1 ± 0.8	–	–
Post-op 3 months	–	–	8.6 ± 2.7	53.8 ± 11.9
Final follow-up	4.2 ± 0.7	–	8.6 ± 2.8	66.7 ± 12.1
<i>t</i>	6.917	7.707	0.274	6.490
<i>P</i>	<0.0001	<0.0001	0.790	<0.0001

Frankel Grades of patients were evaluated as A, B, C, D, and E from poor to good. For statistical analysis wise, 5 Frankel Grades were defined as continuous variables A=1, B=2, C=3, D=4 and C=5, and were analyzed by the paired *t*-test.

fusion rate reached 66.7%, which is higher than previous reported 31.5% to 50%.^[12,13] Moreover, all patients had no instrumentation-caused complications. So far, all these results supported our viewpoint, although the further results at long term should be acquired by the further longer follow-up.

The combined anterior and posterior method is able to achieve the complete decompression of spinal cord at both ventral and dorsal sides. In general, while cervical spine fracture-dislocation occurs, the compression of spinal cord at the dorsal side or the ventral side dominantly comes from the lamina of upper vertebrae, or back edges of lower vertebrae, respectively, which can be eliminated after fracture-dislocation reduction.^[23,24] However, most AS patients suffer severe spine osteoporosis, and the lamina and body of vertebrae are more prone to detach and enter spinal canal. If the decompression is not performed well, the detached bone fragments can cause cervical spinal stenosis and squeeze spinal cord. By the usage of combined anterior and posterior approach, it is easier to get rid of the bone fragments and achieve complete decompression; and the vertebrae body can be cut off during surgery thanks to the enforced internal fixation, which is very difficult to be accomplished by simple anterior method. In our surgery, anterior decompression was performed first to decrease the risk of the neurological deterioration during posterior surgery. According to the evaluation of BI score, the recovery rate of neurological

function of patients was 100%, 4 cases of moderate dependence and 8 of slight dependence at the latest follow-up compared to 10 of severe dependence and 2 of moderate dependence before operation. In previous reports, the recovery rate was 80% of 10 cases by simple the anterior method and 73.7% of total 19 cases by the simple posterior method.^[12,13]

In terms of the high cervical instability, cervical spine restoration is another crucial point for the surgical therapy of cervical spine fracture in AS patients. Some researchers prefer that the fracture reduction should be fully restored to maintain spine order, promote spine fusion, and eliminate the compression on spinal cord from ventral and dorsal side; however, some others suggest that it should be avoided for over-reduction or repeated restoration in the case of second injury by continuous spinal cord compression or stretch by improper restoration. In the current study, the anatomical reduction was achieved only in 25% of patients; however, 100% of patients got satisfied spine fusion and neurological recovery compared to preoperation. So, according to our cases, we recommend that it is the optimal choice to achieve the functional restoration of fractured segments without visible compression rather than the anatomical reduction, if it is difficult to get anatomical reduction due to the high instability of fractured spine (Fig. 2); meanwhile, the robust internal fixation and complete decompression are indispensable to the functional restoration.

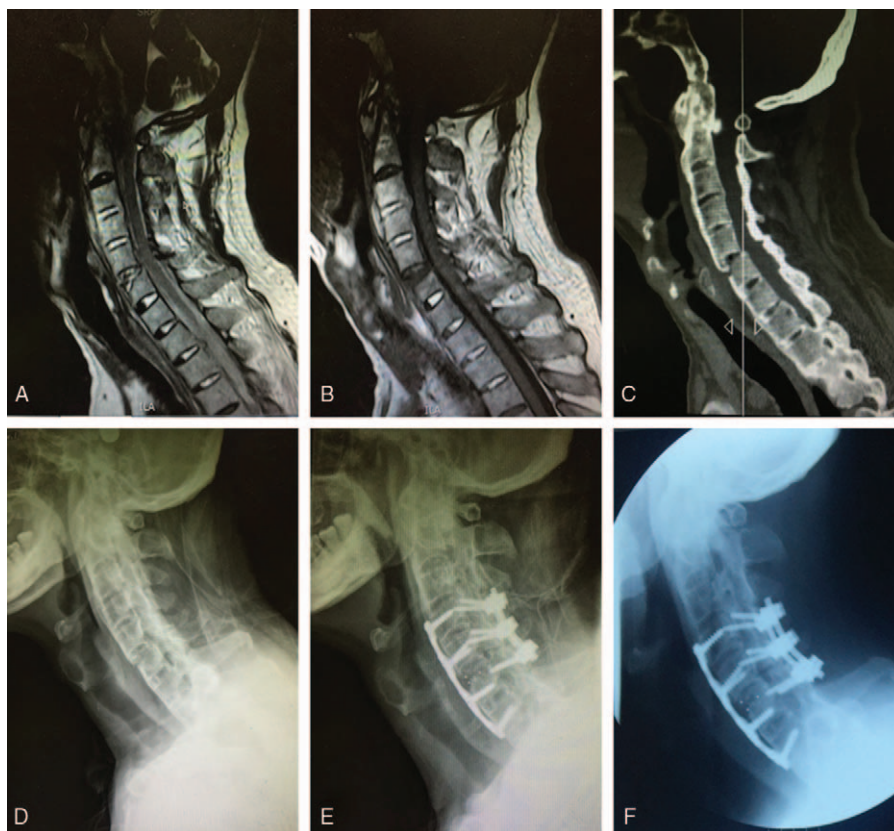


Figure 2. Cervical imaging of a 49-year-old male patient pre- and postoperation. A 49-year-old male patient, suffering ankylosing spondylitis (AS) 22 years, was diagnosed as cervical spine fracture-dislocation with the incomplete spinal cord injury and the fracture of intervertebral disc ligament complex after falling on ground 6 hours. The Frankel grade of neurological function was D, BI score was zero, and SLIC score was 9. The anterior longitudinal ligament and posterior longitudinal ligament of patient were broken. The patient received the emergency surgery for fracture reduction and decompression by 1-stage anterior and posterior method after injury 24 hours. (A–D) Preoperative MRI and CT examination showed the fracture crossing intervertebral discs of C5/6, fracture displacement 2 mm, posterior joint noose, compression in the spine cord. (E) 24 hours after surgery, the cervical fracture and dislocation were reduced from 2 mm before surgery to 1 mm; the functional reduction was achieved and internal fixation was in good condition. (F) Bone fused well at C5/6; Frankel grade was improved to grade E; BI score was 65. AS=ankylosing spondylitis, BI=Barthel index, CT=computed tomography, MRI=magnetic resonance imaging, SLIC=subaxial injury classification.

Regarding of the disadvantage of the combined anterior–posterior approach, it was reported that the long surgery duration and high blood lost led to severe complications, including heart and respiratory failure, and the mortality reached 26.3% in such cases.^[17,19,20,25] In our data, the surgery duration ranged 258.4 ± 28.6 and the blood loss ranged 366.7 ± 57.1 mL. The severe complications, including cardiac arrest, heart failure, and respiratory failure, were not observed, and the death case was not found within perioperative and follow-up stage, suggesting the rapid alleviation of the neurological function by the early surgery and complete decompression may be helpful for the reduction of severe complications. In addition, the robust internal fixation made the patients to be able to get out bed earlier after surgery, which decreased pulmonary infection, respiratory failure.

In this study, all cases have been effectively treated via the combined anterior and posterior method. However, the incidence of AS with severe fracture-dislocation of cervical spine is very low, the very limited cases, only 12 subjects, were included, which resulted in the proper control unavailable for the anterior or posterior treatment. In addition, our average follow-up duration was 25.3 ± 6.6 months, and the long-term efficacy of the combined anterior and posterior method was missed. So, it should be further tested by multiple hospitals with proper control, large sample size, and long-term follow-up in the long run.

5. Conclusions

In the current study, 1-stage surgical therapy via combined anterior–posterior approach produced satisfied efficacy on cervical spine fracture-dislocation in AS patients. Our data indicated that satisfied neurological function recovery accompanied with efficient bony fusion, Cobb angles and stability restoration, good BI score and fewer complications, were achieved by the proper surgery procedure and management at early stage, including robust stabilization, complete spinal decompression.

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