Hemivertebra resection in children, results after single posterior approach and after combined anterior and posterior approach: a comparative study

Kiril Mladenov · Philip Kunkel · Ralf Stuecker

Received: 29 December 2010 / Revised: 3 June 2011 / Accepted: 23 August 2011 / Published online: 11 September 2011
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Abstract

Purpose To compare the results after hemivertebra resection through a single posterior approach and through a combined anterior and posterior approach.

Methods This is a retrospective study on patients treated by hemivertebra resection with monosegmental instrumentation for congenital scoliosis at a single institution. The patients were divided into two groups according to the surgical approach. Both groups were compared for curve correction, complication rate and perioperative data. Paired samples *T* test was used for statistical evaluation.

Results Twenty-five consecutive patients were included. In 12 cases the hemivertebra resection was performed through a single posterior approach (SPA) and in 13 via a combined anterior and posterior approach (CAPA). Curve correction was similar in both groups (59 vs. 55%, $p > 0.05$). Duration of surgery (272 vs. 319 min) and postoperative mechanical ventilation were shorter in the SPA group (5 vs. 30 h), but did not reach statistical significance ($p > 0.05$). Significant blood loss necessitating blood transfusion was observed in six patients operated through an SPA and in 8 patients operated through a CAPA. The duration of the ICU management (1 vs. 3 days) and the hospital stay (12 vs. 19 days) were significantly shorter in the SPA group ($p < 0.05$). Less surgery related general complications were observed in the SPA group (0 vs. 38%).

Conclusions Similar correction of the main and the compensatory curves can be achieved with single posterior

and combined anterior and posterior hemivertebra resection. Benefits of the SPA are lower complication rate and shorter recovery period.

Keywords Congenital scoliosis · Hemivertebra resection · Single posterior approach

Introduction

Curve progression is observed in 75% of the patients with congenital scoliosis [1] and surgical correction is needed in about 50% of the cases [2–4].

Hemivertebra resection (HVR) is currently the method of choice for the treatment of progressive congenital spinal deformity due to a single hemivertebra [1].

The classical technique comprises a circumferential exposure of the spinal column by means of combined anterior and posterior approach (CAPA) [5]. Good correction of up to 70% for the main curve has been reported [6–12]. However, the rate of the perioperative general complications remains significant and varies in the literature between 1 and 46% [13–16].

Recently a hemivertebra resection through a single posterior approach (SPA) has been introduced [17]. The correction of the main and the compensatory curves are similar to those obtained with the combined approach [18–20].

The aspects of those two surgical techniques in terms of complications and surgery related morbidity are not well studied. The benefits of the SPA are still unclear.

In this study the results after hemivertebra resection through a CAPA and through an SPA with emphasis on correction and perioperative complications were compared.

K. Mladenov (✉) · P. Kunkel · R. Stuecker
Department of Pediatric Orthopedic Surgery,
Altona Children's Hospital, Bleickenallee 38,
22763 Hamburg, Germany
e-mail: mladenow_kiril@yahoo.com

Materials and methods

This is a retrospective study on patients treated by HVR for progressive congenital spinal deformity due to an isolated hemivertebra at a single institution in the period 1998–2008. The inclusion criteria were: hemivertebra resection through a CAPA or an SPA, age at surgery under 18 years, complete medical record and X-ray file. Patients with multiple vertebral anomalies and those with associated relevant neuromuscular or collagen diseases were excluded.

The patients were divided into two groups according to the type of the surgical procedure.

Until 2002 the surgical technique described by Lazar et al. [11] was used for the hemivertebra resection through a CAPA. In 2003 the surgical technique described by Ruf et al. [17] was introduced and used since then for the hemivertebra resection through an SPA. Posterior pedicle screw only or hybrid screw-laminar hook instrumentation was used in all patients. All patients were immobilised in a Risser cast for 6 weeks after surgery, sitting was allowed immediately. After this period a thoraco-lumbar brace was given for additional 6 months and the patients were mobilised in the upright position.

The following data were gathered from the medical records: age at surgery and at the latest follow-up, the duration of surgery, the duration of the postoperative mechanical ventilation, the duration of ICU stay and the hospital stay, the need for perioperative blood transfusion, the presence of postoperative general and neurologic complications.

Standardised standing PA and lateral X-rays were used for radiological evaluation. The following parameters were evaluated before surgery and at the last follow-up: magnitude of the main and the compensatory curves, local kyphosis, coronal and sagittal balance, and quality of fusion (pseudarthrosis). Paired samples *T* test was used for statistical evaluation. The level of significance was set at $p < 0.05$.

Results

Twenty-five patients fulfilled the inclusion criteria and a total of 28 HVR were performed (Table 1).

Fifteen hemivertebrae in 12 patients were resected through an SPA. In three patients two independent hemivertebrae were resected in the same surgical setting. In thirteen patients the hemivertebra resection was performed through a CAPA.

The mean age at the time of surgery in the SPA group was 68 ± 42 months and in the CAPA group 69 ± 48 months. The mean follow-up in the SPA group was

29 ± 9 months and in the CAPA group 53 ± 29 months. The demographic data are summarised in Table 1.

Curve correction

SPA group

The main curve in the coronal plane measured before surgery was $39^\circ \pm 10^\circ$ and was corrected to $16^\circ \pm 10^\circ$ at the latest follow-up. The mean curve correction measured $23^\circ \pm 12^\circ$, representing 59% correction at the latest follow-up (Fig. 1).

The compensatory cranial and caudal curves measured before surgery were $14^\circ \pm 11^\circ$ and $11^\circ \pm 14^\circ$, respectively, which were corrected to $5^\circ \pm 7^\circ$ and $2^\circ \pm 5^\circ$ at the latest follow-up showing 65 and 82% correction.

The coronal trunk balance (C7–S1 plumbline AP) was abnormal (>25 mm) before surgery in one patient. All patients had coronal balance within normal limits at the latest follow-up.

Preoperative local kyphosis was present in 3 patients and measured 21° , 15° , and 20° , this was corrected on the latest follow-up to 12° , 8° , and 10° , showing a mean correction of 50%.

Sagittal trunk balance was abnormal (>25 mm) before surgery in 2 patients and was restored or remained within normal limits in all patients at the latest follow-up (Table 2).

CAPA group

The main curve measured before surgery was $40^\circ \pm 11^\circ$ and was corrected to $18^\circ \pm 15^\circ$ at the latest follow-up. The mean curve correction measured $21^\circ \pm 10^\circ$ representing 55% correction at the latest follow-up (Fig. 2).

The compensatory cranial and caudal curves measured before surgery $14^\circ \pm 15^\circ$ and $23^\circ \pm 14^\circ$, which were corrected to $7^\circ \pm 9$ and $12^\circ \pm 11^\circ$ at the latest follow-up showing 50 and 48% correction, respectively.

The coronal trunk balance (C7–S1 plumb line AP) was abnormal (>25 mm) before surgery in three patients. All patients had coronal balance within normal limits at the latest follow-up.

Preoperative local kyphosis was present in three patients and measured 35° , 30° , and 35° , this was corrected to 5° , 26° , and 30° on the latest follow-up, showing good correction in one and poor correction in two patients.

Sagittal trunk balance was normal before surgery and remained within normal limits in all patients at the latest follow-up (Table 2).

The Cobb value before and after surgery and the amount of curve correction are summarised in Table 2.

Table 1 Demographic data for age at surgery, follow-up, surgical approach, localisation of the deformity and associated anomalies in group SP (single posterior approach) and group CAPA (combined anterior and posterior approach)

Pat nr.	Age at surgery	Follow-up (Mo)	Surgical approach	Localisation	Associated anomaly
1	52	26	SPA	L1	
2	113	24	SPA	L3	Kidney, Filum lipoma
3a	127	40	SPA	L2	Anus agenesis
3b		40	SPA	L4	
4a	23	36	SPA	L2	Diaphragmatic hernia
4b		36	SPA	L4	
5	49	27	SPA	L3	VACTERL
6a	57	25	SPA	L2	
6b		25	SPA	L4	
7	164	24	SPA	L5	
8	48	26	SPA	L2	
9	54	55	SPA	L3	
10	62	30	SPA	L3	
11	51	24	SPA	T9	Fallot
12	27	27	SPA	L2	
Average	68	29			
16	156	31	CAPA	T9	
17	18	78	CAPA	T10	
18	167	88	CAPA	T10	
19	35	29	CAPA	T11	
20	66	25	CAPA	L2	
21	91	49	CAPA	L2	
22	31	45	CAPA	T8	Dextrocardia, Persistent foramen ovale
23	66	27	CAPA	T12	Chromosome 6,16 anomaly
24	21	47	CAPA	T12	VATER, Tethered cord
25	78	109	CAPA	T11	
26	24	95	CAPA	T12	
27	96	26	CAPA	L4	
28	48	44	CAPA	L5	
Average	69	53

Fig. 1 Congenital scoliosis due to a fully segmented hemivertebra L3 in a 4-year-old patient. Main curve 31°, compensatory cranial curve 21°, and caudal curve 19° (a, b). Last follow-up 4.5 years after

hemivertebra resection through a single posterior approach, main curve corrected to 5°, good sagittal balance

Table 2 Preoperative and postoperative values for main curve, compensatory curves and coronal and sagittal balance

Pat nr.	Cobb main		Absolute Cobb correction (°)	Cobb correction (%)	Compensatory cranial		Compensatory caudal		C7–S1 AP		C7–S1 Sag	
	Pre op	Last follow-up			Pre op	Last follow-up	Pre	Last follow-up	Pre op	Last follow-up	Pre op	Last follow-up
1	34	16	18	52	0	0	0	0	3	0	-13	25
2	48	11	37	77	28	10	12	0	24	13	0	0
3a	38	18	20	52	0	0	0	0	14	0	0	0
3b	38	18	20	52								
4a	15	8	7	46	15	14	0	0	58	20	20	28
4b	20	9	11	55								
5	53	30	23	43	22	23	18	6	1	5	-36	-44
6a	36	30	6	16	0	0	0	0	17	11	11	54
6b	33	5	28	84								
7	45	28	17	37	0	0	0	0	0	0	0	0
8	46	2	44	95	18	0	9	0	0	24	7	13
9	31	5	26	83	21	0	19	0	10	7	0	-36
10	42	14	28	66	20	5	0	0	0	0	-35	0
11	41	29	12	29	18	10	40	18	5	17	5	11
12	47	8	39	82	27	3	32	0	7	0	0	0
Average	39	16	23	59	14	5	11	2	13	9	-4	5
16	22	8	14	63	9	6	24	14	6	7	0	0
17	60	52	8	13	35	24	30	30	14	6	20	-8
18	54	32	22	40	4	11	34	16	0	0	0	0
19	38	10	28	73	0	0	34	6	0	0	0	0
20	34	0	34	100	14	0	23	0	0	0	0	0
21	24	11	13	54	32	24	20	35	49	5	-13	2
22	52	40	12	23	0	0	32	12	6	8	0	48
23	39	17	12	30	5	2	24	10	15	5	0	0
24	38	18	20	52	7	3	30	11	16	7	0	0
25	35	20	15	42	0	6	45	20	42	3	4	5
26	38	3	35	92	34	0	0	0	48	6	0	40
27	45	10	35	77	38	15	0	0	0	0	0	0
28	38	10	28	73	0	0	0	0	0	15	10	0
Average	40	18	21	55	14	7	23	12	15	5	2	7

a and b describe local deformity in case of double hemivertebra, C7–S1 AP describe coronal balance and C7–S1 Sag describes sagittal balance

Fig. 2 Progressive congenital scoliosis due to a semi-segmented hemivertebra L3 in a 5-year-old patient. Main curve 34°, compensatory cranial curve 14°, and caudal curve 23° (a, b). Last follow-up

2 years after hemivertebra resection through a combined anterior and posterior approach, complete correction of the main and the compensatory curves, preserved sagittal balance (c, d)

Perioperative data

SPA group

Duration of surgery without cast application was on an average 272 ± 109 min. Homologous blood transfusion was necessary in 6 cases (50%). The transfused volume was 231 ± 179 ml. Five patients 41% needed mechanical ventilation after the end of the surgical procedure, three of them had double hemivertebra resection in the same surgical setting. The remaining seven patients were extubated immediately after the end of the surgical procedure. The duration of the ICU management was 1 ± 1 day and the duration of hospital stay was 12 ± 4 days.

No intraoperative and no general surgery related post-operative complications were observed. Solid fusion was present in all patients at the latest follow-up (Table 3).

The surgery in the subgroup that sustained simultaneous resection of two hemivertebra was more extensive as compared to the rest of the patients in the SPA group. The duration of surgery in this subgroup was on average 410 min (326, 393 and 511 min). Blood transfusion was needed in two of the three patients and all three patients needed mechanical ventilation after the end of the procedure for 24, 65 and 13 h.

Neurologic abnormalities were encountered in 1 of the 12 patients in the SPA group (unilateral foot drop due to L5 neurapraxia). Neurologic symptoms were transitory and resolved completely 4 weeks after surgery.

CAPA group

Duration of surgery without cast application was 319 ± 68 min. Homologous blood transfusion was necessary in 8 cases (61%). The transfused volume was 168 ± 74 ml. Eleven patients (85%) needed mechanical

ventilation after the end of the surgical procedure for a mean of 30 ± 43 h. The duration of the ICU management was 3 ± 2 days, and the duration of hospital stay was 19 ± 3 days. Solid fusion was present in all cases at the latest follow-up.

Five of 13 patients (38%) had general surgery related complications such as pleural effusion ($n = 3$), bowel atony with subileus ($n = 1$), lung atelectasis ($n = 1$). Those resolved without sequelae but needed intensive therapy.

One patient had transient paresthesia and right lower extremity pain immediately after surgery. The symptoms resolved completely on the fourth postoperative day (Table 3). The perioperative data are summarised in Table 3.

Statistical analysis

Age at surgery, main curve and compensatory curve magnitude before surgery were similar in both groups ($p > 0.05$).

At the latest follow-up, there was no statistically significant difference in the main curve and the compensatory curve magnitude and the percentage of curve correction between both groups ($p > 0.05$).

The amount transfused blood tended to be higher in the SPA group, but did not reach statistical significance ($p > 0.05$). The higher blood loss in the SPA group was partially due to the fact that in three patients a simultaneous two-level HVR was performed. The number of the patients who needed perioperative blood transfusion was similar in both groups.

Mechanical ventilation after the end of the surgical procedure was longer in the CAPA group as compared to the SPA group (12 vs. 30 h), but the difference did not reach statistical significance ($p = 0.467$).

Table 3 Perioperative data

Pat nr.	Duration of surgery (min)	Transfusion (ml) cell saver	Donor blood	Extubation (h)	ICU stay (days)	Hospital stay (days)	Complications
1	175		250	0	0	15	
2	170			0	0	9	
3	511			24	2	15	
4	393		130	65	5	15	
5	225		130	0	0	11	
6	326	270	580	13	2	11	
7	310			19	1	17	
8	167			0	0	9	
9	326			27	2	20	
10	295	160	100	0	1	8	Acute neurapraxia L5
11	170		200	0	1	10	
12	190			0	1	8	
Average	272		231	12	1	12	
16	175			0	1	18	
17	375		200	25	3	18	
18	276			0	2	22	
19	260		130	14	2	23	
20	299		130	6	3	19	Pleural effusion
21	329		130	7	2	22	
22	328		250	168	7	23	Bowel atony
23	300		300	26	6	18	Right lower extremity paresthesia
24	440		100	25	3	14	
25	405			16	2	19	Lung oedema
26	370		100	27	6	19	Pleural effusion, atelectasis
27	289			45	2	18	Pleural effusion
28	306			26	1	16	
Average	319		168	30	3	19	

Duration of surgery in the SPA group was shorter as compared to the CAPA group (272 vs. 319 min) the difference did not reach statistical significance ($p > 0.05$). The duration of ICU care and hospital stay in the SPA group were significantly shorter ($p < 0.05$, $p < 0.0001$).

Discussion

Hemivertebra resection is currently used in the treatment of progressive congenital spinal deformity due to an isolated hemivertebra.

In our series, 59% correction of the local deformity was achieved through the SPA and 55% correction with the CAPA.

Ruf et al. [18] reported on the correction of the main curve after single posterior hemivertebra resection of 70%. The mean curve correction was 27° and was only 4° superior as compared to the results obtained in our study (average correction in the SPA group 23°). Our results are comparable with other authors reporting 54–64% main curve correction after SPA [19, 20] and 64% to 71% after CAPA [10, 12, 13, 21].

Cranial and caudal compensatory curve correction was 65 and 82% in the SPA group and 50 and 48% in the CAPA group. The slightly better correction in the SPA group was most probably due to the fact that more patients with lumbar hemivertebra were present in this group.

Pseudarthrosis has been recognised as a cause for curve progression after hemivertebra resection. Winter et al. [22]

observed 9% and Bollini et al. [13] observed 14% pseudarthrosis after hemivertebra resection through a CAPA. There were no pseudarthroses in our series in neither group.

The precise evaluation of perioperative blood loss is difficult. We are not aware of any study taking into account the amount lost on dressings and through drainages. Some authors used haemoglobin value for the evaluation of perioperative bleeding [13]. However, haemoglobin level depends not only from the perioperative blood loss but also from the parenteral fluid intake, and cannot be used as a reliable parameter. We used the need for blood transfusion in order to evaluate perioperative bleeding. The criteria for blood transfusion set at our institution are haematocrit under 24% and the need for oxygen supplementation to reach an SpO₂ of above 90%.

Fifty percent of the patients in the SPA group and 61% of the patients in the CAPA group needed perioperative blood transfusion of 231 and 168 ml, respectively. The difference showed no statistical significance ($p > 0.05$).

Surgery related complications after combined anterior and posterior spinal surgery in the paediatric population remain high. Slabaugh [23] reported on seven patients sustained hemivertebra resection via CAPA. There were one lethal (14%) and three neurologic (42%) complications in their series. Bollini et al. [12] found 21% complications related to the anterior approach.

Grossfeld et al. [16] studied the complication rate after anterior and posterior surgery in 230 children with congenital spinal deformity. Severe complications were defined as potential life threatening condition or death and were observed in 8% of the patients. Moderate complications such as ileus, atelectasis or pleural effusions were reported in 39.4% of the cases. One of the main risk factors was the open thoracotomy.

In contrast, Jalanko et al. [24] reported minor complications in 40% of the patients after single posterior hemivertebra resection and in 8% of the patients operated through CAPA.

The results in our study show a significantly higher rate of perioperative complications related to the combined anterior and posterior surgical approach. None of the patients operated through an SPA had surgery related complications. Pulmonary or abdominal surgery related complications were observed in 5 of the 13 cases (38%) operated through a CAPA.

Neurologic complications were described at a rate between 3 and 37% after combined anterior and posterior hemivertebra resection [12, 25, 26] and in up to 14% after single posterior hemivertebra resection [18, 20].

Transitory neurologic complications were observed in one patient from each group in our study (7 and 8%). Those two patients were operated before the introduction of

intraoperative neuromonitoring (IONM) at our institution. Currently IONM is generally recommended [27] and we use it routinely when performing hemivertebra resection. No neurologic complications were observed since then.

Possible limitations of the present study are the retrospective design and last follow-up before reaching maturity. Since the main purpose was to compare perioperative data with two different surgical approaches, this issue has no relevance for the short and medium-term complication rate, but may influence correction results with longer follow-up. Lost of correction after hemivertebra resection was described by Winter et al. [22]. These authors found that all the patients presented with loss of correction had pseudarthrosis. Curve progression after hemivertebra resection and monosegmental fusion of 2° after 4 years [19] and 3.7° after 10 years has been reported [20]. All patients in our study showed solid fusion at the latest follow-up, thus only minimal curve change can be expected with longer follow-up.

Conclusions

Good curve correction in the coronal and in the sagittal plane can be achieved with hemivertebra resection through an SPA and through CAPA. The need for homologous blood transfusion with those two approaches is comparable.

The benefits of the single posterior hemivertebra resection are significantly lower complication rate and shorter postoperative recovery period.

Surgery related morbidity can be significantly reduced with the use of single posterior hemivertebra resection for congenital spinal deformity.

Conflict of interest None.

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