ORIGINAL ARTICLE

The anatomical locations of postoperative pain and their recovery trajectories following Posterior Spinal Fusion (PSF) surgery in Adolescent Idiopathic Scoliosis (AIS) patients

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ABSTRACT

Introduction: This study looked into the different anatomical locations of pain and their trajectories within the first two weeks after Posterior Spinal Fusion (PSF) surgery for Adolescent Idiopathic Scoliosis (AIS).

Methods: We prospectively recruited patients with Adolescent Idiopathic Scoliosis (AIS) scheduled for PSF surgery. The anatomical locations of pain were divided into four: (1) surgical wound pain; (2) shoulder pain; (3) neck pain; and (4) low back pain. The anatomical locations of pain were charted using the visual analogue pain score at intervals of 12, 24, 36, 48 hours; and from day-3 to -14. Patient-controlled analgesia (morphine), use of celecoxib capsules, acetaminophen tablets and oxycodone hydrochloride capsule consumption were recorded.

Results: A total of 40 patients were recruited. Patients complained of surgical wound pain score of 6.2±2.1 after surgery. This subsequently reduced to 4.2±2.0 by day-4, and to 2.4±1.3 by day-7. Shoulder pain scores of symptomatic patients peaked to 4.2±2.7 at 24 hours and 36 hours which then reduced to 1.8±1.1 by day-8. Neck pain scores of symptomatic patients reduced from 4.2±1.9 at 12 hours to 1.8±1.1 by day-4. Low back pain scores of symptomatic patients reduced from 5.3±2.3 at 12 hours to 1.8±1.1 by day-12.

Conclusions: Despite the presence of different anatomical locations of pain after surgery, surgical wound was the most significant pain and other anatomical locations of pain were generally mild. Surgical wound pain reduced to a tolerable level by day-4 when patients can then be comfortably discharged. This finding provides useful information for clinicians, patients and their caregivers.

KEY WORDS:
Pain, Adolescent Idiopathic Scoliosis, Spinal fusion, Deformity, Surgery

INTRODUCTION

Posterior Spinal Fusion (PSF) surgery for Adolescent Idiopathic Scoliosis (AIS) is a major surgery which causes much pain for patients.[1-4] Clinical observation showed that other than pain at the surgical wound site, patients also complained of shoulder, neck and low back pain. None of these anatomical locations of pain were scientifically documented or analysed.

Information regarding the different anatomical locations of postoperative pain and how these anatomical locations of pain improve over time offers invaluable information not only for the patients and caregivers but also to the clinicians who manage pain of their patients. Moreover, education about pain management is very important for children or adolescents who will be undergoing surgery.[5] There were previous studies that looked into postoperative pain trajectories in children undergoing major surgeries, but none of them recorded the anatomical locations of pain.[6,7] This study was conducted to investigate the different anatomical locations of pain and their recovery trajectories within the first 2 weeks after PSF surgery among AIS patients.

MATERIALS AND METHODS

We prospectively recruited AIS patients scheduled for PSF surgery from September to December 2015. Written informed consent was obtained from their caregivers. This study was approved by our institutional ethical board. Patients with non-idiopathic scoliosis, known psychological disorders, metabolic bone disease and undergoing revision surgery were excluded. The anaesthesia protocol, surgery protocol and pain management regime were standardized for all patients.

Pain management regime

Prior to skin closure, 2mg/kg Bupivacaine diluted to a volume of 25mL was infiltrated subcutaneously. In the recovery room, all patients received IV morphine patient-controlled analgesia (PCA) with the following preparation: PCA boluses of 1mg morphine with a 5-minute lock-out interval and 4 hourly dose limit of 20mg morphine. PCA morphine was

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provided for at least 48 hours after surgery and was discontinued once consumption was less than 5mg within 24 hours. Oral analgesia in the form of celecoxib (Celebrex®) capsule 200mg once/twice daily and acetaminophen tablets 500-1000mg 6 hourly were commenced as soon as patients were able to tolerate oral intake. After the discontinuation of PCA morphine, breakthrough pain was managed with immediate-release oxycodone hydrochloride (OxyNorm®) capsule 5mg.

Postoperative rehabilitation protocol
Drain was removed between 12 to 24 hours after surgery with drainage of a maximum of 200ml at the time of removal. Dressing was changed and urinary catheter removed at the same time. Patient was then allowed to sit at the edge of the bed. Patient was encouraged to sit up and ambulate as they tolerated (unless severe postural dizziness/nausea).

Data collection
Demographic data, preoperative and postoperative data were recorded. The anatomical locations of pain were divided into (1) surgical wound pain: pain located at surgical wound site; (2) shoulder pain: pain located at the region of the scapula and shoulder joints; (3) neck pain: pain located at the neck above the C7 spinous process; (4) low back pain: pain located at the lumbar paravertebral muscles. The magnitude of postoperative pain was charted using the visual analogue pain score (VAS) at a scale of 0 to 10 at intervals of 12 hours, 24 hours, 36 hours, 48 hours and from day-3 to -14. PCA morphine usage, celecoxib capsules, acetaminophen tablets and oxycodone hydrochloride capsule consumption were recorded. Assessment of pain score after discharge was carried out through daily telephone enquiry.

Power Analysis, Sample Size and Statistical Analysis
The sample size calculation was performed using G*Power software (version 3.1.9.2). All data was stored and analysed using SPSS V22.0 (SPSS Statistics for Windows, IBM Corp., Armonk, New York, USA). Demographic variables were analysed using descriptive statistic and were represented as means, percentages and plotted in graphs.

RESULTS

A total of 40 patients were recruited for this study; 36 were females and four were males. The demographic, operative and postoperative data is shown in Table I. The surgical wound pain scores and number of symptomatic patients was shown in Figure 1 and Table II. The surgical wound pain score was 6.2±2.1 after surgery, which subsequently reduced to 4.2±2.0 by day-4. This score further reduced to 2.4±1.3 by day-7. Fifty percent of patients were asymptomatic by day-11.

The shoulder pain scores and number of symptomatic patients were shown in Figure 1 and Table II. Shoulder pain scores of symptomatic patients peaked to 4.2±2.7 at 24 hours and 36 hours which then reduced to 1.8±1.1 by day-8. Less than half of the patients complained of shoulder pain and 75% were asymptomatic by day-13.

Patients with Upper Instrumented Vertebra (UIV) at T6 or below did not have any shoulder pain after surgery. One patient with UIV at T1 experienced intermittent shoulder pain during the first 36 hours, and from day-8 to day-12. For UIV at T2, 25% to 75% of patients had shoulder pain. For UIV at T3, 68.4% of patients had shoulder pain on day-3 which reduced to 26.3% on day-14. For UIV at T4, 80% of patients experienced shoulder pain at 48 hours which reduced to 40% on day-14.

Table I: Demographic, surgical and post-surgery data

Demographic Data	Mean	SD
Age (years)	15.7	3.6
Preoperative Cobb angle (°)	66.5	16.0
Weight (kg)	46.9	10.3
Height (cm)	156.3	8.2
BMI (kg/m^2)	19.2	3.8
	n	**%**
Gender		
Male	4	10.0
Female	36	90.0
Lenke types		
1	16	40.0
2	7	17.5
3	3	7.5
4	2	5.0
5	8	20.0
6	4	10.0
Operative Data		
	Mean	**SD**
Wound size (cm)	28.9	5.7
Operation time (min)	162.4	59.4
Blood loss (ml)	992.3	559.1
Fusion level	9.8	2.2
Hospital stay (days)	3.8	0.7
Postoperative Data		
After Surgery	**Mean**	**SD**
Time to sitting (hours)	17.7	4.7
Time to ambulation (hours)	29.6	13.4
Time to discharge (hours)	74.9	15.6

SD = Standard Deviation

The neck pain scores and number of symptomatic patients were shown in Figure 1 and Table II. Neck pain scores were below the score of one. Neck pain scores of symptomatic patients reduced from 4.2±1.9 at 12 hours to 1.8±1.1 by day-4. Only about a quarter of patients complained of neck pain and 90% were asymptomatic by day-12.

The low back pain scores and number of symptomatic patients were shown in Figure 1 and Table II. Low back pain scores were the highest at 12 hours with a score of 5.3±2.3. which then reduced to 1.8±1.1 by day-12. About half of the patients complained of low back pain and 70% were asymptomatic by day-11.

There was no significant correlation between the occurrences of low back pain with the Lowest Instrumented Vertebra (LIV). For fusion to T11, one patient had low back pain up to day 12. For fusion to T12, 57.1% had low back pain on day-14. For fusion to L1, 33.3% had low back pain on day 8 and 16.7% by day-13. For fusion to L2, 66.7% had low back pain on day-14. For LIV at L3, 63.2% had low back pain at 48 hours which reduced to 15.8% by day-14. Only 4 patients had LIV at L4 and 50% had low back pain on day-14.

Table II: Number and percentage of symptomatic patients for surgical wound, shoulder, low back and neck pain

SURGICAL WOUND PAIN																
Number and Percentage (%) of symptomatic patients																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
No.	39	40	38	36	36	37	35	34	32	31	28	24	20	19	15	15
Percent	97.5	100	95	90	90	92.5	87.5	85	80	77.5	70	60	50	47.5	37.5	37.5
SHOULDER PAIN																
Number and Percentage (%) of symptomatic patients																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
No.	14	15	17	17	16	18	19	18	20	17	17	16	14	12	10	10
Percent	35	37.5	42.5	42.5	40	45	47.5	45	50	42.5	42.5	40	35	30	25	25
UIV* (n) and Percentage (%) of patient with shoulder pain																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
T1 (1)	100	100	100	0	0	0	0	0	0	100	100	100	100	100	0	0
T2 (4)	25	50	50	25	0	25	75	50	75	50	50	50	50	50	25	50
T3 (19)	42	47.4	57.9	52.6	68.4	63.2	63.2	63.2	63.2	52.6	52.6	36.8	36.8	26.3	26.3	26.3
T4 (5)	40	20	20	80	40	40	20	40	60	40	60	60	60	60	60	40
T5 (2)	100	100	100	100	50	50	50	50	50	0	0	100	0	0	0	0
LOW BACK PAIN																
Number and Percentage (%) of symptomatic patients																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
No.	20	23	23	19	19	23	25	21	19	16	15	13	12	13	12	11
Percent	50	57.5	57.5	47.5	47.5	57.5	62.5	52.5	47.5	40	37.5	32.5	30	32.5	30	27.5
LIV* (n) and Percentage (%) of patient with low back pain																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
T11 (1)	100	100	100	100	0	100	100	100	100	100	0	0	100	100	0	0
T12 (7)	57.1	71.4	57.1	42.9	85.7	57.1	71.4	57.1	42.9	28.6	28.6	42.9	42.9	42.9	42.9	57.1
L1 (6)	16.7	33.3	33.3	0	16.7	0	33.3	16.7	33.3	33.3	16.7	16.7	16.7	16.7	16.7	0
L2 (3)	33.3	66.7	66.7	33.3	66.7	33.3	66.7	66.7	66.7	33.3	33.3	66.7	66.7	66.7	66.7	66.7
L3 (19)	57.9	57.9	63.2	63.2	52.6	57.9	57.9	47.4	36.8	42.1	42.1	26.3	15.8	21.1	21.1	15.8
L4 (4)	50	50	50	50	100	50	100	100	100	50	75	50	50	50	50	50
NECK PAIN																
Number and Percentage (%) of symptomatic patients																
Time	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
No.	9	8	7	9	5	13	10	8	7	8	7	5	5	4	5	4
Percent	22.5	20	17.5	22.5	12.5	32.5	25	20	17.5	20	17.5	12.5	12.5	10	12.5	10

UIV = Upper Instrumented Vertebra, LIV = Lowest Instrumented Vertebra

Table III: Test of significance (P < 0.05) between different types of pain

	12H	24H	36H	48H	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
Surgical Wound																
Shoulder	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	0.04*	< 0.01*	0.01*	0.09	0.38	0.36	0.26	0.60
Neck	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	< 0.01*	0.01*	0.01*	0.03*
Low back	< 0.01*	< 0.01*	< 0.01*	< 0.01*	0.01*	< 0.01*	0.33	0.03*	0.14	< 0.01*	0.03*	0.25	0.58	0.57	0.46	0.75
Shoulder																
Neck pain	0.94	0.45	0.18	0.28	0.22	0.41	0.33	0.21	0.06	0.36	0.22	0.21	0.27	0.30	0.53	0.44
Low back	0.05	0.07	0.53	0.76	0.27	0.30	0.05	0.62	0.94	0.94	0.97	0.96	1.0	1.0	0.98	1.0
Neck																
Low back	0.01*	< 0.01*	0.01*	0.03*	< 0.01*	0.01*	< 0.01*	0.01*	0.01*	0.13	0.09	0.07	0.15	0.15	0.32	0.30

* Significant difference.

Table IV: Average consumption of PCA morphine and oral pain medications

	PCA morphine (mg)	Celecoxib (mg)	Acetaminophen (mg)	Oxycodone hydrochloride (mg)
12H	12.4	90.0	875.0	0.0
24H	7.1	215.0	2275.0	0.0
36H	5.6	150.0	1362.5	0.0
48H	2.1	210.0	1800.0	0.2
D3		190.0	1100.0	1.0
D4		175.0	1275.0	1.4
D5		185.0	1100.0	1.2
D6		175.0	925.0	0.9
D7		150.0	675.0	0.3
D8		130.0	525.0	0.7
D9		130.0	450.0	0.2
D10		115.0	375.0	0.2
D11		100.0	200.0	0.3
D12		85.0	150.0	0.2
D13		65.0	75.0	0.0
D14		55.0	150.0	0.0

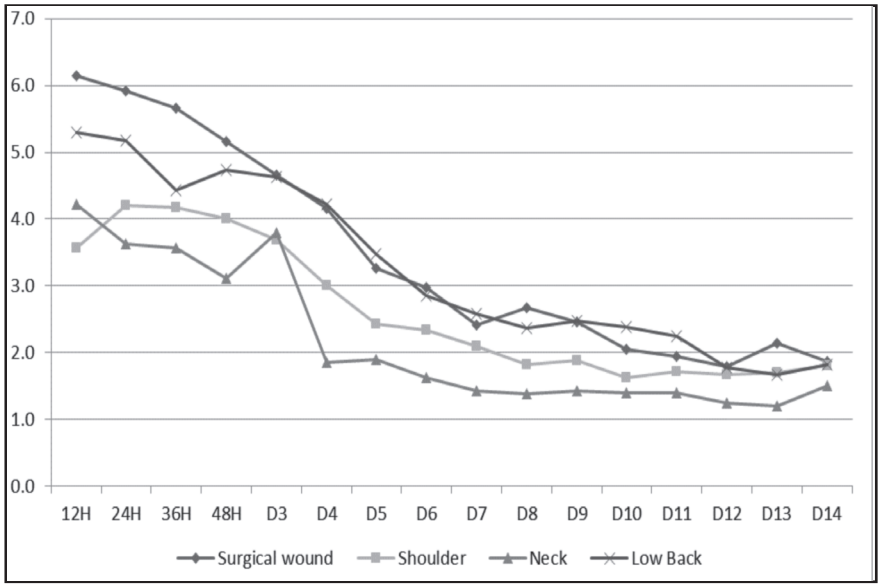

Fig. 1: Types of pain scores in symptomatic patients versus time.

The comparison between the anatomical locations of pain scores in symptomatic patients are shown in Figure 1. Based on the graph, surgical wound pain showed the highest pain score compared to other anatomical locations of pain followed by low back pain, shoulder pain and neck pain. All anatomical locations of pain showed a typical trend of rapid reduction (sharp dip) from day-3 to -6. Patients had pain score of <4 by day-4 to -5 and <2 by day-11 to -12.

Surgical wound pain was significantly higher compared to low back pain and shoulder pain lasting up to day-9. Surgical wound pain was significantly higher than neck pain throughout the whole two weeks. Low back pain was significantly higher than neck pain up to day-7 (Table III).

Table IV shows the consumption of intravenous and oral analgesics during the postoperative period up to day-14. The highest usage of PCA morphine was at 12 hours (12.4mg) and it reduced to 2.1mg at 48 hours. The celecoxib consumption peaked at 24 hours (215.0mg) which then progressively reduced from day-3 to 55.0mg at day-14. A similar trend was noted for oral acetaminophen. Oxycodone hydrochloride consumption was minimal and the highest was 1.4mg at day-4.

DISCUSSION

Postoperative pain following PSF for AIS patient can be severe.[1-4] Kotzer et al.,[1] analysed 93 children (aged 8 to 21 years) who had undergone spine fusion and for four consecutive postoperative days, children were asked to rate the intensity of their pain using the Adolescent Pediatric Pain Tool and observed pain behaviours were recorded using the Child Pain Scale. They found that age, pain tolerance, and severity of operative procedure were associated with pain intensity. Kleiber et al.,[3] studied fifty-nine adolescents and young adults (average age 14 years) undergoing spinal fusion for AIS completed the Sensitivity Temperament Inventory for Pain-Child version (STIP-C) and found that there was a small but significant correlation between the Perceptual Sensitivity and Symptom Reporting subscales of the STIP-C and pain intensity measured on the third postoperative day. Rullander et al.,[4] invited 87 young people aged 8-25 years with scoliosis who underwent corrective surgery from 2004 to 2007 to complete a questionnaire and found that severe global postoperative pain during the hospitalization period and persistent and recent onset pain after discharge amongst these patients. Therefore, patients undergoing corrective surgery require an intense postoperative pain management regime such as PCA with opioids,[8-10] continuous opioids with acetaminophen and nonsteroidal anti-inflammatory drug as adjuncts,[11,12] epidural anaesthesia in combination with other analgesics[8,9,13,14] and multimodal postoperative analgesia regime.[15,16] In children or adolescents the impact of pain stimuli does not end when the painful experience is over[17,18] and pain memories can lead to future distortion experiences of pain.[19-21] Therefore, adequate pain management for children or adolescent undergoing major surgery is crucial.

Established reports document preoperative and postoperative anxieties to be factors that can lead to increase pain postoperatively.[22,23] Therefore, interventions such as cognitive-behavioural interventions targeted to reduce anxiety had been described to reduce postoperative pain.[2,22] Parental anxiety was also known to influence the anxiety of patients and postoperative pain perception.[7,22] Amongst the modifiable factors that can reduce patient anxiety, preoperative pain information was found to be the most effective.[2,24] Thus, knowledge about the postoperative anatomical locations of pain and trajectories prior to surgery may reduce patient and parental anxiety which in effect may lead to less perceived postoperative pain.

Our study showed that pain at the surgical wound area was the most significant pain experienced by patients. This was

followed by low back pain and shoulder pain. Neck pain was the least significance. Only surgical wound pain had the average pain score of above five. Low back pain had the average score between five to three up to day 6. Both shoulder and neck pain had an average score of <4. From these findings, we can postulate that surgical wound pain was the most significant pain, followed by low back pain which affected some patients, and both shoulder and neck pain were generally negligible in most patients.

The surgical pain reduced postoperatively from moderate pain score of six to a tolerable pain score of four approximately at the 4th day and to minor negligible pain score of <2 within the 7th day. The reduction of pain to <4 after postoperative day-4 coincides with the average hospital stay of 3.8±0.7 days. Patients were discharged on day-4 post surgery when pain was tolerable and when the requirement of parenteral PCA morphine was not needed. We also found that by day-11, 50% of patients were pain free.

In the symptomatic patients in our study the surgical wound pain reduced to a tolerable pain score of <4 by day-5 and a negligible pain score of <2 by day-11. The low back pain reduced to a tolerable pain score of <4 by day-5 and a negligible pain score of <2 by day-12. The shoulder pain reduced to a tolerable pain score of <4 by day-3 and a negligible pain score of <2 by day-8. The neck pain reduced to a tolerable pain score of <4 within 24 hours and a negligible pain score of <2 by day-4. Therefore, pain at all anatomical locations in symptomatic patients reduced to a tolerable level by day-3 to -5 and a negligible level in less than two weeks.

We noted that patients with UIV at T6 or lower did not complain of any shoulder pain but was present in patients with fusion up to T1 to T5. However, we did not have adequate number of patients to analyse statistically. This was one of the limitations of this study. On the contrary, the level of LIV had no significant effect on the incidence of low back pain. Even though the cause of shoulder pain could not be concluded from this study, we postulate that this pain might be related to muscle dissection or insertion of extrapedicular screws through the costovertebral joint that were frequently needed in the proximal thoracic spine.

We encouraged patients to sit up and ambulate early and the mean time for sitting from end of surgery was 17.7±4.7 hours and time for ambulation was 29.6±13.4 hours. This does not have a negative effect on the pain trajectory during the first two days but pain scores continued to reduce. This finding is useful when advising patients and caregivers regarding postoperative pain as they may misconceive that sitting up and ambulating early may result in the worsening of pain and delay in recovery.

The pain felt by patients was influenced not only by the actual pain stimuli but also by their perception of pain. Another limitation of this study was that it did not examine the psychosocial factors that may affect the magnitude of pain experienced by patients.

With our findings, we can counsel AIS patients and their caregivers that despite the presence of pain at different anatomical locations after surgery, surgical wound pain remain as the most significant pain postoperatively, and that other anatomical locations of pain were generally mild or even negligible. The surgical wound pain reduced to a tolerable level by day-4 and to a negligible level within a week. Patients can be comfortably discharged by day-4 with oral analgesics. Even if the patient developed significant low back, shoulder or neck pain, this generally resolves quickly to a tolerable level by day-3 to -5 and to a negligible level in less than two weeks.

CONCLUSIONS

Other than the pain over the surgical wound, patients commonly complain of pain over other anatomical locations such as the shoulder, neck and low back. These complain are commonly ignored by the surgeons and were considered as part of the global postoperative pain. The locations of pain were divided into; (1) surgical wound pain: pain located at surgical wound site; (2) shoulder pain: pain located at the region of the scapula and posterior shoulder joints; (3) neck pain: pain located at the neck above the C7 spinous process; (4) low back pain: pain located at the lumbar paravertebral muscles. Despite the presence of different anatomical locations of pain after surgery, pain at the surgical wound was the most significant compared to other locations such as low back, shoulder or neck pain. Pain was either absent, mild or resolves rapidly within two weeks after surgery. The knowledge of the anatomical locations of postoperative pain, their significance and their trajectories within the first two weeks after PSF surgery for patient with AIS provided useful information for clinicians, patients and their caregivers.

ETHICAL APPROVAL

This research received institutional ethical board approval (MECID No: 201510-1753).

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