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Is there an Increase in Intra-operative Bleeding during Emergency Hybrid Open-Door Laminoplasty for Post-traumatic Cervical Cord Patients?

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Abstract

Study Design: Retrospective Cohort Study

Objectives: There are no reports describing the potential increase in intra-operative blood loss with the use of hybrid open-door laminoplasty in post-traumatic cervical cord injuries.

Summary of background data: Early surgical intervention for traumatic cervical cord injury has demonstrated outcome benefits but is not without complications.

Methods: A retrospective review of patients who underwent open-door hybrid laminoplasty by a single surgeon was performed. Patients were divided into 2 groups- Group A: isolated traumatic spinal cord injury without vertebral fracture, Group B: non-traumatic spinal cord injury.

Results: 30 consecutive patients, of whom 8 had isolated traumatic cervical injury, underwent hybrid open-door laminoplasty. A longer mean operative time (254 vs 199 minutes, p=0.005), hospital stay (44.1 vs 11.1 days, p=0.006) and ICU or high dependency unit stay (10.3 vs 1.5 days, p=0.004) was noted in the traumatic patients when compared to the non-traumatic patients. A greater amount of intraoperative blood loss was found in the traumatic patients (median 350 ml; range 110-750) and less in the non-traumatic patients (median 130 ml; range 50-400, p=0.032). Patients in both groups showed post-operative neurological recovery with a JOA score improvement of 1.9 ± 3.1 (p=0.14) in the traumatic group and 1.4 ± 1.7 (p=0.001) in the non-traumatic group.

Conclusions: Emergency open-door hybrid laminoplasty can be performed in patients with traumatic spinal cord injury. While early surgical decompression for post-traumatic patients improves neurological outcomes, a higher intra-operative bleeding should be anticipated in post-traumatic patients.

Introduction

Cervical laminoplasty is a treatment of choice for cervical myelopathy involving more than 3 spinal segments [1,2] and is associated with a significantly lower rate of complications and reduction in range of motion of the neck, compared to other anterior cervical surgical techniques [3-6]. A multi-center, international prospective cohort study by Fehlings et al. looked at 313 patients from 6 North American spine centers and compared early versus late surgical decompression for traumatic cervical spinal cord injuries [7]. The study found that early surgical decompression within 24 hours was associated with better neurological outcomes and fewer post-operative complications. Another study by the same group of investigators, looking at cost-utility analysis on the same cohort of patients, found that early spinal decompression was also more cost-effective [8]. Cervical laminoplasty is a treatment of choice for cervical myelopathy involving more than 3 spinal segments [1,2] and is associated with a significantly lower rate of complications and reduction in range of motion of the neck, compared to other anterior cervical surgical techniques [3-6]. A multi-center, international prospective cohort study by Fehlings et al. looked at 313 patients from 6 North American spine centers and compared early versus late surgical decompression for traumatic cervical spinal cord injuries [7]. The study found that early surgical decompression within 24 hours was associated with better neurological outcomes and fewer post-operative complications. Another study by the same group of investigators, looking at cost-utility analysis on the same cohort of patients, found that early spinal decompression was also more cost-effective [8].

However, early emergency surgery when performed in post-traumatic cervical cord patients is not without complications [9-11]. The perceived complications may be related to the hyperaemic state of the surgical field in the traumatized spine [12].To the best of the author's knowledge; no paper describes the potential blood loss with the use of open-door hybrid laminoplasty in traumatic cervical cord injuries. This study aims to examine intra-operative blood loss in patients who underwent emergency open-door hybrid laminoplasty for traumatic cervical injury versus patients who underwent elective open-door hybrid laminoplasty in non-traumatic cervical myelopathy.

Methods

A retrospective review of 30 consecutive patients who underwent open-door hybrid laminoplasty by a single spine surgeon was conducted from 2010-2020. Patients were divided into 2 groups, Group A: patients who sustained isolated post-traumatic cervical cord injury without vertebral fracture and Group B: patients with non-traumatic cervical myelopathy. Pre- and post-operative clinical and surgical outcomes were analyzed using SPSS Statistics Version 21 (IBM Corporation). NHG Domain Specific Review Board (DSRB) approval was obtained for the study.

The motion-sparing hybrid open-door laminoplasty technique

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is a modified muscle-sparing technique of the traditional open-door laminoplasty [13]. The hybrid open-door laminoplasty technique incorporates a C4-6 open-door laminoplasty with instrumentation to reduce laminar door closure, a C3 dome-like osteotomy, and an upper C7 partial laminectomy (Figure 1,2). This technique preserves the semispinalis cervicis muscle attachments at the C2 level and the trapezium muscle attachments at C7, to reduce the incidence of postoperative axial neck pain and cervical kyphosis [14-17].

Statistical analysis was performed using IBM Statistical Package for Social Science (SPSS) Version 24.0 (IBM Corp, 2016). Pearson's chi-squared analysis and independent t-tests were used to compare the demographic variables and outcome variables between both groups. A p-value of < 0.05 was considered significant in our study.

Results

A total of 30 patients were analyzed in the study. Group A (traumatic) included 8 male patients with a mean age of 62.6 (52-76) years. Group B (non-traumatic) included 22 patients, of which 12 were male and 10 were females, with an average age of 62.5 (45-73) years. An average of 5.1 (range 5-6) cervical segments were operated on. There were no significant statistical differences between the two groups in terms of age and number of vertebral segments operated except for gender (p=0.03). A summary of the patient demographics can be found in Table 1.

In traumatic group A, there were 4 patients with American Spinal Injury Association (ASIA) Impairment scale A, 1 patient with ASIA C, and 3 patients with ASIA D. The mean pre-operative JOA score of the traumatic group was 6.9 ± 4.6. In non-traumatic group B, 20 patients had cervical spondylotic myelopathy and 2 patients had ossification of a posterior longitudinal ligament. The mean JOA score of non-traumatic Group B was 13.1 ± 2.0. For traumatic surgery, the median time delay to operation was 3 days (range 0-20). There was significantly longer mean operative time (255 vs 199 minutes, p=0.023), mean hospital stay (44.1 vs 11.1 days, p=0.003) and mean ICU or high dependency unit stay (10.3 vs 1.5 days, p=0.002) noted in the traumatic group when compared to the non- traumatic group.

A significantly greater amount of blood loss was noted in the traumatic group (median 400 ml; range 110-1000) when compared to the non-traumatic group (median 140 ml; range 50-1500, p=0.014). Excluding the two outliers (Table 2), a similar result is observed with a greater amount of blood loss found in the traumatic group (median 350 ml; range 110-750) as compared to the non-traumatic group (median 130 ml; range 50-400, p=0.015). None of the patients required post-operative blood transfusion

Although a poorer pre-operative JOA score was noted in the traumatic group when compared to the non-traumatic group (6.9 vs 13.1, p<0.001), both groups showed neurological improvement postoperatively. While there was a trend towards an improvement in postoperative JOA score, only the non-traumatic group had a statistically significant JOA score improvement. The mean JOA score improvement was 1.4 ± 1.7 (p=0.001) in the non-traumatic group and 1.9 ± 3.1 (p=0.62) in the traumatic group (Table 3).

Post-operatively, in the traumatic group, 1 pre-operative tetraplegic (ASIA A) patient died on post-operative day 7 from respiratory complications. There was also 1 case of superficial wound infection, which resolved after a course of oral antibiotics. In the non-traumatic group B, there was 1 case of superficial wound infection which resolved with oral antibiotics. A summary of the post-operative complications is found in Table 4.

Discussion

The benefits of early surgical decompression in post-traumatic spinal cord injury patients are well documented in the literature [7-11]. A meta-analysis of 9 articles by Liu et al. showed that urgent surgical decompression within 24 hours improved the neurological outcome when compared to late surgery [18]. However, emergent and early surgical decompression of this traumatized cervical cord are not without complications. A retrospective study of 1060 patients by Samuel et al. showed that waiting to optimize the general health of the patient before proceeding with surgical decompression is

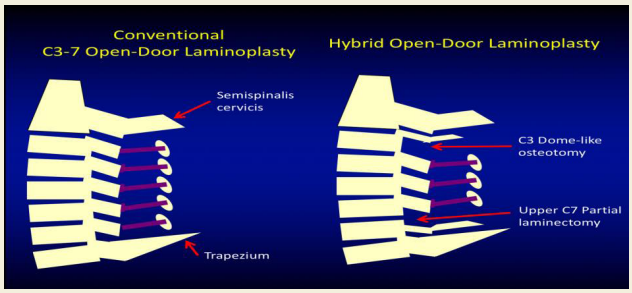

Figure 1: Hybrid open-door laminoplasty technique as compared to a conventional C3-7 open-door Laminoplasty: C4-6 open-door laminoplasty with instrumentation to reduce laminar door closure, a C3 dome-like osteotomy and an upper C7 partial laminectomy.

Figure 2: Post-operative X-rays of a patient who underwent C3-7 hybrid open-door laminoplasty.

Table 1: Patient Demographics.

	Traumatic (Group A)	Non-traumatic (Group B)	p-value (*statistically significant)
Total no. of cases	30		
No. of cases	8	22	
Age (years); Range	62.6 (52-76)	62.5 (45-73)	0.98
Gender	8 males	12 males; 10 females	0.030*
Diagnosis	• 2 central cord syndrome • 1 fracture and dislocation - ASIA A: 4; ASIA B: 0; ASIA C: 1; ASIA D: 4	20 Cervical Spondylotic Myelopathy 2 ossification of posterior longitudinal ligament	

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Table 2: Blood Loss Clinical Data.

No.	Age	Gender	Trauma/Non-trauma	Blood loss (ml)	Operation time (min)	Pre-op JOA	Post-op JOA
1	58	Female	Non-traumatic	400	240	11	15
2	60	Male	Non-traumatic	280	257	11	15
3	68	Male	Non-traumatic	100	279	14	16
4	68	Male	Non-traumatic	100	227	16	16
5	70	Male	Non-traumatic	100	199	13	15
6	63	Male	Non-traumatic	1500*	258	12	16
7	56	Male	Non-traumatic	130	145	14	16
8	63	Male	Non-traumatic	50	173	11	14
9	73	Female	Non-traumatic	50	146	13	12
10	45	Female	Non-traumatic	150	192	16	16
11	61	Male	Non-traumatic	250	201	16	17
12	59	Female	Non-traumatic	100	173	14	16
13	69	Female	Non-traumatic	150	190	14	16
14	63	Male	Non-traumatic	250	148	10	9
15	50	Female	Non-traumatic	100	113	12	13
16	58	Female	Non-traumatic	400	190	11	11
17	65	Female	Non-traumatic	300	223	nil	nil
18	69	Female	Non-traumatic	100	192	16	16
19	58	Male	Non-traumatic	100	167	15	15
20	60	Male	Non-traumatic	350	249	12	13
21	72	Female	Non-traumatic	100	167	11	15
22	68	Male	Non-traumatic	200	250	14	14
23	52	Male	Traumatic	500	240	4	5
24	62	Male	Traumatic	1000*	440	7	15
25	60	Male	Traumatic	700	238	5	7
26	65	Male	Traumatic	150	196	4	5
27	67	Male	Traumatic	60	192	4	7
28	62	Male	Traumatic	400	266	4	4
29	57	Male	Traumatic	180	188	10	13
30	76	Male	Traumatic	300	279	17	14

*outliers

Table 3: Clinical Parameters.

	Traumatic (Group A)	Non-traumatic (Group B)	Difference	p-value (*statistically significant)
Median Blood Loss(ml); Range	400; 110-1000	140; 50-1500	271	0.014*
Median Blood Loss (without outliers); Range (ml)	350; 110-750	130; 50-400	230	0.015*
Blood transfusion	Nil	Nil		NA
Operation time (mins)	255 (±82.3)	199(±44.1)	73	0.023*
Length of hospital stay (days)	44.1 (±39.7)	11.1(±15.8)	28.8	0.003*
ICU + SHD stay (days)	10.3(±12.3)	1.5(±1.4)	7.9	0.002*
Preop JOA	6.9 (±4.6)	13.1 (±2)	5.9	<0.001*
Post-op change in JOA	1.9 (±3.1)	1.4 (±1.7)		0.62

Table 4: Post-op Complications.

	Traumatic (Group A)	Non-traumatic (Group B)
Post-op Complications	• 1 preoperative ASIA A patient died on POD 8 from pneumonia	• 2 urinary tract infections

associated with decreased mortality and may be more beneficial [19]. may be explained by the hyperemic surgical field seen in post-traumatic patients. Kobrine et al. reported that there was an increased blood flow in the spinal cord of monkeys after traumatic cervical cord injury. This was postulated to be secondary to a combination of the increase in the metabolic demand of the spinal cord, a loss of autoregulation, and subsequent vascular dilatation as a direct result of the trauma to the spinal cord [20]. Furthermore, because most bleeding comes from the epidural space, hence when one chooses the open door laminoplasty technique, there is a potential concern of epidural vein trauma during laminoplasty gutter preparation. Greuters et al. noted a high prevalence of coagulopathy in post-traumatic brain injury patient [21] while Yang et al. found that patients with traumatic spinal cord injuries have a greater

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incidence of acute coronary events [22]. These studies highlighted the volatility of the vascular status in post-traumatic cervical cord patients and their greater risk of intraoperative bleeding. Increased intra-operative bleeding increases post-operative morbidity, disease burden, and demands more post-operative resources to manage the post-traumatic cervical spine patients [12,23-27]. Hu et al, in a review article of spinal deformity surgery, conceptualized that significant blood loss can result in greater fluid shifts which affect cardiac function, increase coagulopathy, postoperative hematoma formation with potential neurologic compromise, and increases the risk of postoperative spinal infection [23]. Similarly, Yu et al reported that excessive blood loss in cervical spine surgery leads to complications including Greuters et al. noted a high prevalence of coagulopathy in post-traumatic brain injury patients [21] while Yang et al. found that patients with traumatic spinal cord injuries have a greater incidence of acute coronary events [22]. These studies highlighted the volatility of the vascular status in post-traumatic cervical cord patients and their greater risk of intraoperative bleeding.

Increased intra-operative bleeding increases postoperative morbidity, disease burden, and demands more post-operative resources to manage the post-traumatic cervical spine patients [12,23-27]. Hu et al, in a review article of spinal deformity surgery, conceptualized that significant blood loss can result in greater fluid shifts which affect cardiac function, increase coagulopathy, postoperative hematoma formation with potential neurologic compromise, and increase the risk of postoperative spinal infection [23]. Similarly, Yu et al reported that excessive blood loss in cervical spine surgery leads to complications including postoperative anemia, hypotension, hematoma formation, and inadequate oxygenation of organs, and resulted in poor postoperative patient outcomes [24]. Other authors reported that increased intraoperative blood loss was associated with specific postoperative cervical spine complications. Fineberg et al found that acute posthemorrhagic anemia from surgical blood loss was a risk factor for perioperative cardiac events in cervical spine surgery [25]. Awad et al reported that excessive blood loss of more than 1litres was a significant risk factor for postoperative epidural hematoma formation [12] whereas Sagi et al found that blood loss of greater than 300ml was predictive of airway complications and re-endotracheal tube intubation post anterior cervical spine surgery [27]. In our study, increased intraoperative blood loss may be related to increased operative time and postoperative hospital stay. This may be due to poor surgical field visualization and subsequent increased time required to arrest the aggressive intraoperative epidural bleeding [28]. To the best of the author's knowledge, this is the first study to compare intra-operative blood loss in emergent versus elective hybrid open-door laminoplasty. One of the limitations to this study is the small patient sample size. Nonetheless, this study demonstrates the possibility of increased intraoperative bleeding during emergency hybrid open-door laminoplasty in the current trend of emergent surgical decompression of traumatic cervical cord injury patients. Should emergent posterior laminoplasty technique be employed, we would recommend the potential use of additional surgical maneuvers to reduce intraoperative blood loss. These include the use of tranexamic acid [28,29], cell saver [30], or the use of French door laminoplasty [31] to avoid epidural bleeding from the open door laminoplasty gutter [32,33].

Conclusion

The current study suggests that hybrid open-door laminoplasty can be performed in patients with traumatic spinal cord injury. While early surgical decompression for post-traumatic patients improves neurological outcomes, higher intra-operative bleeding should be anticipated in post-traumatic patients.

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