Clinical Research

Factors Effecting the Frequency of Surgical Site Infections After Spinal Surgery and the Efficiency of Negative Pressure Wound Therapy (NPWT) Used For Treatment; A Retrospective Clinical Study

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ABSTRACT

Objective: We aimed to evaluate the frequency and possible causes of surgical site infections (SSI) after spinal surgeries, and the efficiency of negative pressure wound therapy (NPWT) in the treatment.

Material and Method: Patients with at least 12 months of follow-up who were operated for spinal pathologies in the same institution between 2019-2021 were included in the study. The medical records of the patients were reviewed retrospectively. Age, gender, diagnosis for spinal surgery, leghth of instrumentation level, severity of SSI, preoperative hgb, postoperative hgb, preoperative albumin levels, CRP, sedimentation, culture results, number of NPWTs performed, NPWT costs, wound healing time and whether revision was required were examined and the findings were recorded. The same NPWT systems were used for treatment of SSIs and same treatment algorithm was performed.

Results: A total of 269 patients were included to the study. A total 14.1% SSI was detected. Although statistically there was no relationship between the reason of spinal surgery and SSI rate, the incidence of SSI was higher among patients operated for congenital spinal pathologies (21,8%). However, for the patients having SSI; longer segments were instrumented, preoperative albumin levels were lower, and preoperative immobilization and debility were more frequent. The wounds of 33 patients were completely healed with NPWT and were closed. The severity of SSI was significantly worse in the congenital spinal pathologies and tended to be particularly worse in patients with spina bifida. Also, it was observed that, the later the SSI had appeared and the later the treatment had started, the more sever the SSI had appeared. No significant correlation was found among congenital spinal pathologies and healing rate of wounds with NPWT.

Conclusion: NPWT is an effective tool in treatment of SSIs after spinal surgeries. However, care must be taken for spina bifida patients before surgery. Because remediating the SSIs in these patients may be difficult. Longer level of instrumentation, preoperative low albumin levels and preoperative immobilization and debility are indicative factors for SSI. Careful and respectful dissection of the soft tissue, preoperative albumin replacements and early intervention of the infection may be effective to prevent and/or ease the SSIs treatment after spinal surgeris.

Keywords: *Spine Surgery, Surgical Site Infections, Congenital Spinal Deformity.*

ÖZ

Spinal Cerrahi Sonrası Cerrahi Alan Enfeksiyonlarının Sıklığına ve Tedavide Kullanılan Negatif Basınçlı Yara Tedavisinin (NBYT) Etkinliğine Etki Eden Faktörler; Retrospektif bir Klinik Çalışma

Amaç: Spinal cerrahi sonrası cerrahi alan enfeksiyonlarının (CAE) sıklığını ve olası nedenlerini ve tedavide negatif basınçlı yara tedavisinin (NBYT) etkinliğini değerlendirmeyi amaçladık.

Gereç ve Yöntem: 2018-2020 yılları arasında aynı kurumda omurga patolojileri nedeniyle opere edilmiş en az 12 ay takibi olan hastalar çalışmaya dahil edildi. Hastaların tıbbi kayıtları retrospektif olarak incelendi. Yaş, cinsiyet, spinal cerrahi tanısı, enstrümantasyon seviyesinin uzunluğu, cerrahi alan enfeksiyonu (CAE) şiddeti, preoperatif hgb, postoperatif hgb, preoperatif albumin seviyeleri, c reaktif protein (CRP), sedimentasyon, kültür sonuçları, yapılan NBYT sayısı, NBYT maliyetleri, yara iyileşme süresi ve revizyon gerekip gerekmediği incelendi ve bulgular kaydedildi. CAE'lerin tedavisi için aynı NBYT sistemleri kullanıldı ve aynı tedavi algoritması uygulandı.

Bulgular: Çalışmaya 269 hasta dahil edildi. Toplamda %14,1 (n =38) CAE saptandı. Spinal cerrahi nedeni ile CAE oranı arasında istatistiksel olarak ilişki bulunmamakla birlikte (p =0,306), konjenital spinal patoloji nedeniyle opere edilen hastalarda CAE insidansı daha yüksekti (%21,8). Ancak CAE geçiren hastalarda; daha uzun segmentler enstrümante edildi, preoperatif albümin seviyeleri daha düşüktü ve preoperatif immobilizasyon ve halsizlik daha sıktı (sırasıyla p =0,025, p <0,001 ve p =0,025). Otuzüç hastanın (%86.8) yaraları NBYT ile tamamen iyileşti ve kapatıldı. CAE şiddeti konjenital spinal patolojilerde anlamlı olarak daha kötüydü ve özellikle spina bifidalı hastalarda daha kötü olma eğilimindeydi (sırasıyla p =0.017 ve 0.011). Ayrıca CAE ne kadar geç ortaya çıkarsa ve tedavi ne kadar geç başlarsa CAE o kadar şiddetli görünüyordu (p =0.018, pearson rho =0.537). NBYT ile konjenital spinal patolojiler ile yaraların iyileşme hızı arasında anlamlı bir ilişki bulunmadı (sırasıyla p =0.098 ve 0.229).

Sonuç: NBYT, omurga ameliyatlarından sonra CAE'lerin tedavisinde etkili bir araçtır. Ancak spina bifida hastalarında ameliyat öncesinde dikkat edilmesi gerekir. Çünkü bu hastalarda CAE'leri düzeltmek zor olabilir. Daha uzun enstrümantasyon seviyesi, preoperatif düşük albümin seviyeleri ve preoperatif immobilizasyon ve halsizlik CAE için belirleyici faktörlerdir. Yumuşak dokunun dikkatli ve saygılı diseksiyonu, preoperatif albümin replasmanları ve enfeksiyona erken müdahale spinal cerrahi sonrası CAE tedavisini önlemede ve/veya kolaylaştırmada etkili olabilir.

Anahtar Sözcükler: *Omurga Cerrahisi, Cerrahi Alan Enfeksiyonları, Konjenital Spinal Deformite.*

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Negative pressure wound therapy (NPWT) is being used in an increasing trend for the treatment of chronic infections and the closure of wounds (1). Although its use was popularized for chronic infected wounds at first, the early and promising results boost its use in all aspects of medicine related to wound closure, including acute wound management, the down-staging of complex trauma prior to surgery, wound bed preparation, surgical site infections (SSI) after spinal surgery, the treatment of periprosthetic and peri-implant infections, and the management of patients with a poor operative risk as a standard of care (2). The NPWT has been shown to increase oxygenation, remove debris, and promote granulation at the wound. In addition, later-developed automated, controlled, commercially available systems (i.e., vacumm-assisted closure (VAC)) have enabled the delivery of continuous or intermittent installation with negative pressure to wounded tissues (NPWTi), which has claimed to increase the neovascularization and alleviate the infection better than standard systems (3).

SSIs after spinal surgery are very serious complications. The presence of a spinal implant renders management more intricate, and complications can involve different tissue zones, including the subcutaneous, subfascial, osseous, and disc spaces. For deeper infections, the probability of neurological damage and the presence of a chronic infection increases (4). Elderly age (>60), higher levels of instrumentation, diabetes, obesity, smoking, hypertension, alcohol abuse, complex procedures, poor physiological status, traditional open approaches, surgery for kyphosis, and prior SSIs have been reported to increase the incidence of SSI after spine surgery (5, 6).

NPWT has started to be used successfully to treat SSIs and wound complications after spinal surgeries as well (7). But only a few studies have evaluated the risk factors for SSIs after congenital spinal pathologies and adult spinal pathologies together and evaluated the figure e efficiency of NPWT for these different groups of spinal pathologies as well (8, 9). In this study, our first hypothesis was that SSIs after spine surgeries are more common among patients with congenital scoliosis, as surgery in this group is more challenging, more levels of vertebrae need to be implanted, and most of the cases are bedridden and are not doing well physiologically. The second hypothesis was that NPWT is an effective method to remediate the SSIs in patients operated on for congenital spinal pathologies. But more time and effort are needed for these patients to achieve the closure of the wound.

MATERIAL AND METHOD

After obtaining institutional ethics committee approval (ID: B10.1.TKH.4.34.H.GP.0.01/130), the medical records of the patients who were operated on for spinal pathologies in a single center between September 2018 and September 2020 were reviewed retrospectively. This study was conducted in accordance with principles for human experimentation as defined in the Declaration of Helsinki. Informed consent was obtained from all individuals prior to surgery.

The inclusion criteria were as follows: having the necessary medical records, including laboratory surveys, culture results, and follow-up data for at least 12 months of follow-up; being operated on for fracture, congenital scoliosis, lumbar spinal stenosis, cervical spinal stenosis, disc herniation, spondylolisthesis, idiopathic scoliosis, denovo scoliosis, malignancy, thoracic kyphosis, discitis, and revision surgeries of these pathologies; The congenital spinal pathologies group consisted of formation-segmentation defects, spina bifida, and neuromuscular scoliosis. Patients who did not have adequate medical records and did not complete the 12-month follow-up period, patients under 4 years of age and patients over 80 years of age were excluded from the study.

Patients; age, gender, spinal pathology, preoperative ambulation level, number of instrumentation levels, degree of surgical site infection, preoperative; Hgb, albumin, CRP, and sedimentation levels, postoperative; existence of SSI, Hgb, culture results, number of debridements, number of NPWTs used, costs of NPWTs used, wound healing time, and need for revision due to infection were examined, and the findings were recorded.

The wound healing time was the interval between the first debridement and complete wound closure. Patients were defined as mobile and immobile, depending on the individual's preoperative ambulation levels. Immobile patients were either wheelchair-dependent or totally bedridden. Mobile patients could be ambulated, at least with crutches. Infections occurring at the surgical site within the first year postoperatively were considered SSI. SSIs occurring at postoperative 3 weeks were considered to be acute; SSIs between 3 and 12 weeks were subacute; and SSIs after 12 weeks to 12 months were chronic. The frequency of debridement's was classified as debridement only once, debridement twice, and multiple debridement's (3 or more debridements) (10).

Positive wound bacteria culture results with elevation in CRP, sedimentation, and WBC, swelling at the surgical site, purulent drainage of the wound or appearance of the sinus tract, and dehiscence of the wound were defined as SSI (11). Also, continuous purulent drainage of the wound with dehiscence and elevation of CRP, sedimentation, and WBC was defined as a surgical site infection independent from culture results. Although serohemorrhagic drainages occurring in the early postoperative period were not considered infected unless they turned purulent character, prophylaxis was applied with antibiotics approved by the infectious diseases specialist to prevent infection of the postoperative hematoma until the drainage decreased. If the drainage turned into a purulent character or did not stop despite appropriate supportive treatments for 1 week, it

was considered infected, and debridement was performed.

SSIs were classified according to the United States Centers for Disease Control and Prevention (CDC) criteria: Grade 1) superficial necrosis, wound dehiscence, or superficial infection; Grade 2) deep infection beyond the fascia with or without wound dehiscence, Grade 3) implants, disc, or bone are involved; or wound dehiscence with exposed implants (12).

Management of SSI and treatment algorithm

Antibioteraphy alone was not used for any patient who was thought to have SSI. NPWT was performed in every patient with persistent wound drainage after 72 hours postoperatively. An incisional VAC (Confort NPWT C300®, Confort Med. Inc. Turkey) used within antibiotics for acute infections without dehiscence initially. With this system, a 125mmHg negative wound pressure was applied to the wound to allow the suction of the hematoma and exuda (13). If SSI could not be remediated, wounds were debrided, and a standard NPWT system using sterile sponges was used to prevent the infection from going deeper. The same VAC systems were used in all patients (Confort NPWT C300®, Confort Med. Inc. Turkey) After debridement and removal of necrotic and infected debris, wounds were dressed with silver coated sterile sponges and closed with drapes. A standard 125 mm/hg negative wound pressure was applied to the wound.

Cultures were taken during all debridements and VAC change sessions. Broad-spectrum prophylactic antibiotics were started for SSI patients initially. Final antibiotherapy was initiated by infectious diseases specialists after having the causative organism in cultures. The duration of the antibiotherapy was approved by these specialists depending on the age, weight, causative organism, stage of the infection, and comorbidities of the patients.

VAC was changed in bed or under anesthesia depending on the size of the wound and the need for debridement once in 4 to 5 days. The amount of sponges used for the dressing was lessened at every session to allow the wound to get smaller in size. The incision was closed after achieving the granulation of the wound and obtaining normal levels of acute-phase reactants. Depending on the size, wounds were closed under anesthesia, either primarily or with appropriate skin flap grafts.

Statistical Analyses

Data were analyzed using SPSS software (ver. 22.0; IBM Corp., Armonk, NY, USA). The normality of the data distribution was evaluated by the Shapiro-Wilk test. Students T test and One way anova tests were used to compare quantitative data between independent groups. Categorical variables were compared using the Pearson chi-squared test and Monte Carlo simulations with Fisher's exact test. The Pearson correlation coefficient (rho) was calculated as a measure of the associations between categorical variables (1 =perfect positive correlation and-1 =perfect negative correlation). Quantitative variables are expressed as mean ± standard deviation and minimum and maximum values. Qualitative variables are expressed as frequencies or ratios. P-values < 0.05 were considered to indicate statistical significance.

RESULTS

A total of 285 patients data were reviewed retrospectively. Of these 16 patients, 16 were excluded from the study. Six of them had died within the first six months after surgery, and 10 of them were lost to follow-ups. 231 patients were remediated without any surgical site complications. However, 38 (14.1%) of 269 patients sustained an SSI (Table 1).

Table 1. *Demographic data and characteristics of the patients.*

	Surgical site infection (SSI) group (n =38) (Mean, Std. Deviation, Min/Max)	Patients without infection (n =231) (Mean, Std. Deviation, Min/Max)	p
Age (Years)	38,11 ±27,47(4-76)	41,55±25,6(4-87)	0,448
Gender (F/M) (n)	23/15	138/93	0,927[pc]
Length of İnstrumentation (level number)	9,53±4,21(2-16)	7,73±4,62(0-21)	**0,025**
Preoperative Albumin(g/l)	30,7±5,1(21-46)	35,1±6,24(18-48)	**0,0001**
Preoperative Hgb(g/dl)	12,6±1,6(9,8-15,7)	12,3±1,8(7,3-17)	0,418
Postoperative Hgb(g/dl)	10,4±1,9(5,4-14)	10,6±1,6(6,3-15,1)	0,414
Postoperative decrease amount in Hgb levels	2,18±1,2(0,3-5,5)	1,79±1,36(0-7)	0,105
Preoperative CRP(mg/dl)	9,7±7,8(0,0-35,2)	4,48±(0,0-203)	0,135
Preoperative Sedimentasyon(mm/h)	56,05±20,3(20-94)	55,6±35,9(20-191)	0,951
Erythrocyte Transfusion (unit)	0,89±0,953(0-4)	0,77±1,07(0-6)	0,487
Duration of follow-up (months)	14,9±2,8(12-29)	17,5±5,4(12-29)	**0,002**
Ambulation level of the patient. (mobile/immobile) (n)	22/16	187/44	**0,025**[pc]
Palmer-Parker Mobility Score	4,34	6,59	**0,000**

Std. Deviation; Standart Deviation, Min/Max; Minimum/Maximum, Hgb; Haemoglobin, CRP; C reactive protein, P; Oneway Anova Test, Pq; Pearson Chi-quare Test.

No significant relationship was detected between SSIs and the diagnosis of surgery (p =0.306) (Table 2).

Table 2. *The relationship between the diagnosis and surgical site infection.*

Diagnosis	Surgical site infection (SSI) group (n)(within raw%) (within column%)	Patients without infection (n) (within raw%) (within column%)	Total
Lumbar spinal stenosis	10 (14,9%) (26,3%)	57 (85,1%) (24,7%)	67 (100,0%) (24,9%)
Congenital spinal deformity	12 (21,0%) (31,5%)	45 (78,9%) (26,4%)	57 (100,0%) (29,0%)
Neuromuscular scoliosis	5(23,8%) (13.1%)	16(76,2%) (6,9%)	21 (100%) (7,8%)
Vertebra fracture	6 (8,2%) (15,8%)	67 (91,8%) (29,0%)	73 (100,0%) (27,1%)
Spondylolisthesis	1 (25,0%) (2,6%)	3 (75,0%) (1,3%)	4 (100,0%) (1,5%)
Cervical spinal stenosis	0 (0,0%) (0,0%)	3 (100,0%) (1,3%)	3 (100,0%) (1,1%)
Revision surgery	1 (33,3%) (2,6%)	2 (66,7%) (0,9%)	3 (100,0%) (1,1%)
Spina bifida revision	1 (50,0%) (2,6%)	1 (50,0%) (0,4%)	2 (100,0%) (0,7%)
Disc herniation	1 (25,0%) (2,6%)	3 (75,0%) (1,3%)	4 (100,0%) (1,5%)
Denovo scoliosis	0 (0,0%) (0,0%)	2 (100,0%) (0,9%)	2 (100,0%) (0,7%)
Idiopathic scoliosis	0 (0,0%) (0,0%)	20 (100,0%) (8,7%)	20 (100,0%) (7,4%)
Discitis + Osteomyelitis	0 (0,0%) (0,0%)	3 (100,0%) (1,3%)	3 (100,0%) (1,1%)
Malignancy	1 (16,7%) (2,6%)	5 (83,3%) (2,2%)	6 (100,0%) (2,2%)
Thoracic kyphosis	0 (0,0%) (0,0%)	3 (100,0%) (1,3%)	3 (100,0%) (1,1%)
Total	38 (14,1%) (100,0%)	231 (85,9%) (100,0%)	269 (100,0%) (100,0%)

Pearson Chi- Square test.

In addition, no correlation was found between the patients' age, gender, preoperative Hgb, postoperative Hgb, preoperative CRP, preoperative sedimentation, erythrocyte transfusion, and SSIs. The duration of the follow-up period was longer for infection-free patients (p =0.002). However, for the patients having SSI, longer segments were instrumented, preoperative albumin levels were lower, and preoperative immobilization and debility were more frequent (respectively, p =0.025, p =0.0001, and p =0.025)

When the patients were evaluated in terms of Palmer-Parker mobility score, the mean score was 4.34 in patients with surgical site infection and 6.59 in patients without infection (14) (p =0.000) (Table 1).

The causative bacteria could be generated from the cultures taken from 29 of the patients. However, causative bacteria could not be generated in 9 (23.6%) patients. Although in 14 patients a single bacteria was found to be the causative, in 15 patients a polymicrobial bacterial environment was detected.

Of the 12 infected congenital spinal deformity, 3 had segmentation and formation pathologies, 9 had spina bifida (Figure 1).

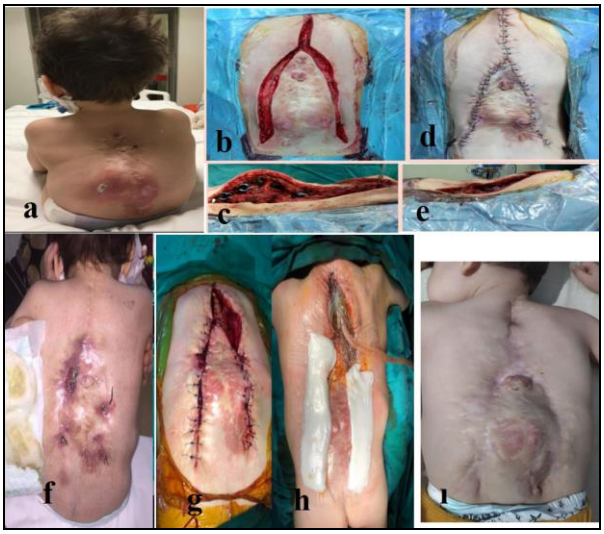

Figure 1. *a) Five years old boy with spina bifida and lumbar kyphosis. b) Reverse Y incision to prevent postoperative wound complications. c) Sagittal view before kyphectomy and fixation with sliding-growing rod technique. d) View after closure of the wound. e) Sagittal view after kyphectomy and sliding-growing rod technique. f) SSI and exposure of the implants at postoperative 8th week g,h) Image taken at 16.th debridmen and NPWT session. Despite whole efforts, infection could not be defeated. Thus all implants are removed at postoperative 10th. month after achiavement of fusion. An additional 4 debridments were performed and wound was closed at 20.th session. I) Image showing closed wound at postopeartive second year.*

Neuromuscular scoliosis was also present in 5 patients (Figure 2).

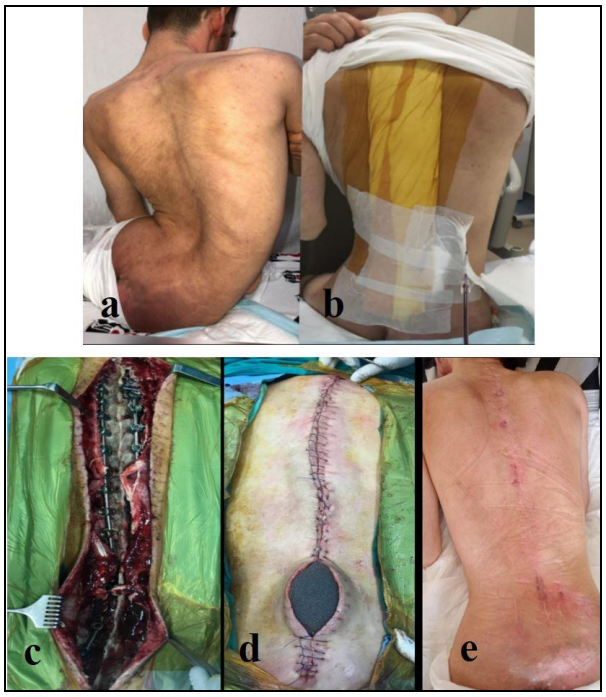

Figure 2. *a) Twenty-one years old boy with neuromuscular lumbosacral scoliosis. b) Early postoperative image showing correction of spine with T2-iliac posterior instrumentation c) Patient sustained an early postoperative SSI and recurrent radical debridments were performed. d) Image at 4th debridment session showing subtotal closure of the wound. e) Image showing complete healing and infection free wound after 6 sessions of debridment at postoperative 13.th month.*

In addition, no significant difference was found between spina bifida, neuromuscular scoliosis, and formation and segmentation defects in terms of the development of SSIs (p =0.319).

Of the patients with SSIs who could not be treated successfully with NPWT, 2 were operated on for spina bifida, 2 for segmentation and formation defects, and 1 for lumbar spinal stenosis. Instrumentation was performed for 12-15 levels in 4 patients with congenital scoliosis whose wounds could not be remediated successfully. 2 of them had sustained a chronic, 1 subacute, and 1 acute infection. Despite all efforts, infection recurred after the closure of the wounds in this patient several times. All four patients used to have a grade 3 SSI. In these cases, the causal bacteria were Klebsiella, Pseudomonas, Eschericia coli, and Methicillin-Sensitive Staphylococcus Aureus (MSSA). All patients were immobile preoperatively. The implants had to be removed after the achievement of fusion in two patients. However, follow-up with the two patients continues, as fusion could not be obtained after 14 months of follow-up. The other patient whose wound could not be closed with NPWT was a 76-year-old female patient who was operated on for lumbar spinal stenosis. This patient had five levels of instrumentation, and transforaminal lumbar interbody fusions (TLIF) were performed. The patient had sustained an acute grade 3 SSI, and the causative microorganisms were determined to be Klebsiella and Vancomycin-Resistant Enterococci (VRE). Again, despite multiple debridements and closure of the wound, the infection recurred after 16 months of follow-up.

There was only 1 patient in our series with a dural sac tear who developed SSI. This patient was operated on for lumbar spinal stenosis and had sustained an acute grade 2 infection. After a single debridement and NPWT, the wound was free of infection, and the wound was closed at the second session. Any other complication related to the infection was not detected during the 18-month follow-up. Only one patient required skin grafting for wound closure. In this patient, who underwent 8 levels of instrumentation and lumbar kyphosis resection due to spina bifida, a subacute stage 3 SSI had developed. The wound was closed by a split-thickness skin graft obtained from the thigh after nine NPWT exchanges and multiple debridements.

The severity (grade) of SSI was significantly worse in the congenital scoliosis group and tended to be particularly worse in patients with spina bifida (p =0.017 and 0.011, respectively) (Table 3).

Table 3. *Demographic and characteristic features of patients with surgical site infection.*

	Wounds healed with NPWT (n =33) (Mean, Std. Deviation, Min/Max)	**Wounds didn't healed with NPWT (n =5) (Mean, Std. Deviation, Min/Max)**	**p**
Age (Years)	40 ±27,1(4-75)	25 ±29(4-76)	0,258
Gender (F/M) (n)	19/14	4/1	0,339
Length of İnstrumentation (level number)	9,18±4,18(2-16)	11,80±4,087(5-15)	0,200
Preoperative Albumin(g/l)	31,22±5,26(21-46)	27,9±2,80(23-31)	0,180
Preoperative Hgb(g/dl)	12,76±1,60(9,8-15,7)	11,74±1,54(10,4-13,5)	0,192
Postoperative Hgb(g/dl)	10,5±1,9(5,4-14)	9,84±1,95(8,1-13)	0,453
Postoperative decrease amount in Hgb levels	2,22±1,27(0,3-5,5)	1,9±0,9(05-2,9)	0,589
Preoperative CRP(mg/dl)	9,61±8,02(0,0-35,2)	10,84±6,9(3,6-21,2)	0,749
Preoperative Sedimentasyon(mm/h)	57,3±20,4(20-94)	48±20,3(20-77)	0,350
Erythrocyte Transfusion (unit)	0,91±1,01(0-4)	0,8±0,44(0-1)	0,815
NPWTs used (n)	6,94±4,88(1-20)	7±2,9(5-12)	0,979
Duration of NPWT (days)	27,7±19,5(4-80)	28±11,6(20-48)	0,979
Cost for NPWT(usd)	6.535±1,817(2800-6.800)	2,187±837(1650-3,650)	0,744
Duration of follow-up (months)	19,94±6,83(12-29)	15,20±3,04(12-23)	0,938
Onset time of infection **n (within row %) (within column %)**			
Acute	14(87,5%)(42,4%)	2(12,5%)(40%)	
Subacute	9(90%)(27,3%)	1(10%)(20%)	0,895[pq]
Chronic	10(83,3%)(30,3%)	2(16,7%)(40,0%)	
Severity of the infection (CDC classification) **n (within row %) (within column %)**			
Grade 1; Superficial	3(100%)(9,1%)	0(0,0%)(0,0%)	
Grade 2; Over the fascia	14(100%)(42,4%)	0(0,0%)(0,0%)	0,097 [pq]
Grade 3; Deep peri-implant infection	16(76,2%)(48,5%)	5(23,5%)(100%)	
Frequency of debridements **n (within row %)(within column %)**			
Only incisional NPWT	9(100%)(27,3%)	0(0,0%)(0,0%)	
Debrided 1 time	7(100%)(21,2%)	0(0,0%)(0,0%)	0,068 [pq]
Debrided 2 times	5(100%)(15,2%)	0(0,0%)(0,0%)	
Multiple debridments(more than 3 times)	12(70,6%)(36,4%)	5(29,4%)(100%)	
Ambulation level of the patient. (mobile/immobile) (n)	20/13	2/3	0,346 [pq]

Std. Deviation; Standart Deviation, Min/Max; Minimum/Maximum, P; Student T test, Pq; Pearson Chi-quare Test.

Also, a relationship between the groups in terms of SSI occurrence time was not detected (p =0.266). Additionally, it was found that there was no significant difference between the congenital spinal pathologies and other diagnoses in terms of the number of NPWTs used, duration of NPWT treatment, and costs (p =0.552, 0.552, and 0.765, respectively).

While there was no relationship between the length of instrumentation levels and the severity (grade) of SSIs, the instrumentation level was significantly longer in patients with SSIs (p =0.827 and 0.025). As expected, it was found that as the severity of SSI increased, there was a significant increase in the duration of NPWT treatment. (Pearson rho =0.432). In addition, as SSI worsened, the probability of wound closure decreased and the frequency of debridement increased in these cases (Pearson rho =0.341 and 0.715). Also, we found that the later the SSI appeared and the later the treatment was started, the more severe the SSI appeared (p =0.018, Pearson rho =0.537).

DISCUSSION

Spinal surgeries are commonly performed for many different spinal pathologies, and 0.4-20% of SSIs have been reported to occur after these surgeries (15). The use of NPWT in the treatment of SSI has almost become standard. In this study, we evaluated the risk factors that may affect the development of SSI in patients who were operated on for different spinal pathologies and also assessed the success of treatment with NPWT and the factors affecting the success of treatment. In our series, a total of 14.1% SSI was detected. Although statistically there was no relationship between the reason for spinal surgery and the SSI rate, the incidence of SSI was higher among patients operated on for congenital spinal pathologies. However, for the patients with SSI, longer segments were instrumented, preoperative albumin levels were lower, and preoperative immobilization and debility were more frequent. The severity (grade) of SSI was significantly worse in congenital spinal pathologies and tended to be particularly worse in patients with spina bifida (p =0.017 and 0.011, respectively). Also, we found that the later the SSI appeared and the later the treatment was started, the more severe the SSI appeared. (p =0.018, pearson rho =0.537.) Although we had presumed that there may be a significant problem of wound healing rate among the congenital spinal pathologies, no significant correlation was found between the kind of spinal pathology and unsuccessful treatment (p =0.098 and 0.229, respectively).

As stated above, previous studies have reported different factors being indicative of SSIs. Namba et al. (16) have proposed a scoring system to predict SSIs. This scoring system has included blood loss >400 ml, the presence of diabetes mellitus, an emergency operation, a preoperative total serum albumin level <3.2 g/dL, and skin conditions in the patient. The authors have scored every factor with 1 point, and the sums of the scores are classified as follows: 0-1 normal risk, 2 moderately

severe risk, and 3 and above high-risk patients for SSIs after spinal pathology. However, this system has not been validated with further studies yet and needs to be developed. Dyck et al. (13) reported that hypoalbuminemia was a major factor in SSI infection in patients who underwent fusion with posterior instrumentation. Also, a previous review reported <3.5 g/dl preoperative albumin levels as an independent and major risk factor (17). In our series, the mean albumin levels were below <3.5 g/dl as well. But for the patients that could not be remediated with VAC, albumin levels were under <3.5 g/dl for all 5 patients. In our series, if the albumin levels in patients who developed SSI were too low, we tried to intervene with albumin replacement. However, based on our findings, we think that even if albumin levels are corrected, the probability of SSI recovery decreases in patients with low preoperative albumin levels. The amount of intraoperative blood loss is another indicative factor for SSIs. However, this is a debatable issue, and although some studies have reported this factor as an indicative factor, others have not supported this finding (17, 18). Also, our results did not yield a positive correlation between SSIs and blood loss or blood replacement. Nevertheless, we detected that preoperative ambulation levels were more important for predicting SSIs, as preoperatively immobile patients had a statistically significant tendency for SSI after spinal pathologies, despite the fact that previous studies do not support this finding (19). Also, instrumentation levels have been reported to be correlated with the development of SSIs, and seven levels or more of instrumentation have been reported to be independent risk factors for the development of SSI (20). In line with the current study, we detect that increased instrumentation levels increase the probability of having an SSI, but no correlation between the length of instrumentation levels, the grade of the SSI, or the probability of healing of the SSI was detected.

Staphylococcus aureus is the second most common cause of SSI after spinal surgeries (8). However, in our series, causative bacteria could be isolated in cultures from 29 patients. Of these, 15 were infected by more than one organism, 14 were infected with a single organism, and S. aureus was the causative only in 5 cases. Which implies that hospital-acquired transmissions, contamination due to poor in-bed patient care, or inappropriate sterilization of NPWT systems must be kept in mind as a reason for infection as well. Of the patients whose organisms could not be isolated, all had had a grade 1 or 2 acute postoperative infection; all were diagnosed to have infection due to clinical findings; and all were remediated successfully with early debridement and NPWT. On the other side, all 5 patients that could not be remediated with NPWT had a polymicrobial infection, which proves that the treatment process becomes more complex as multibacterial infections deterrify the healing capacity of the host (5, 21).

Treatment of SSIs after spinal pathologies takes a long time, particularly for patients with severe infections. However, reported results have a wide range of variability by means of the duration of treatment, from 3 to 186 days. Whereas, Kurra et al. (7) reported healing after an average of 33 days (3-116 days) for suprafacial (grade 1 and 2) infections and 77 days (7-235 days) for deep (grade 3) infections with NPWT. In line with these studies, independent of the severity of the infection, the mean duration of treatment was 27.7±18.5 (4-80) days in our series. The maximum duration was shorter than that reported. This could be because of differences in management strategies. We prefer to perform radical debridements during NPWT sessions, which enable early infection treatment. Also, we detected that there was a correlation between the severity of the infection and the duration of treatment. The patient with a NPWT treatment period of 80 days had a kyphectomy with congenital lumbar kyphosis with a myelomeningocele defect and a spina bifida in which we had applied a sliding growing rod system after kyphectomy.

The type of surgery also affects the development of SSI. The incidence of SSI has been reported to be around 1% after a simple discectomy and laminectomy and 5% when spinal fusion is involved. However, the incidence is higher in patients operated on for congenital or neuromuscular reasons (20, 21). In our series, we observed SSI in 17 (21.8%) of 78 patients with congenital and neuromuscular scoliosis. But infection was not detected in any of the patients operated on for idiopathic scoliosis (n =20). However, a statistical significance with spinal pathology and SSI could not be detected as the infection rate was quite high among patients operated on for lumbar spinal stenosis (14,9%) as well. Nevertheless, the severity of SSI was significantly worse in congenital spinal pathologies and tended to be particularly worse in patients with spina bifida (p =0.017 and 0.011, respectively). For spina bifida patients, the development of SSI seems to be high and has long-lasting healing processes. Probably due to the fact that the subcutaneous soft tissues of these patients at the apex of lumbar kyphosis are very weak, the corpectomies performed in that area prolong the surgery, and the circulation of the skin is impaired due to wide dissection and retraction during surgery (22).

However, there are no similar large series in the literature regarding the number of spina bifida patients as in this study. Considering this, we think that the entire surgical team should be very careful during the operation of spina bifida patients, and we recommend careful soft tissue dissection and wound closure during surgery.

The major limitation of our study was that it was not a prospective randomized study, and the duration of surgery was not evaluated due to inappropriate records. Furthermore, a functional assessment could not be carried out for patients sustaining SSI. However, the relatively large number of patients (particularly with congenital spinal pathologies) constitutes the major strength of the study.

Conclusion

The incidence of SSI is higher among patients operated on for congenital spinal pathologies. Because those are very complex and stiff pathologies that need to be treated with more sophisticated and long-term procedures. Although NPWT is an effective tool in the treatment of SSIs after spinal surgeries, it does not enable 100% success. Moreover, the ability to heal with NPWT is independent of the reason for surgery and is correlated with the severity of the infection. Longer levels of instrumentation, preoperatively low albumin levels, and status of mobilization and debility are indicative factors for SSI. Preoperative albumin replacements and early intervention of the infection may prevent and/or ease the SSI's treatment after spinal surgery.

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