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Clinical Study

Effects of diabetes and smoking on lumbar spinal surgery outcomes

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ABSTRACT

Smoking and diabetes have long been considered risk factors for poor surgical outcome. However, the precise role of smoking and diabetes in the development of poor outcome in lumbar spinal surgery remains ambiguous. This study was undertaken to determine the effects of diabetes and smoking specifically on lumbar spinal surgery outcomes. A retrospective cohort study studied 902 patients who underwent lumbar spinal surgery at the Royal Melbourne Hospital, Australia, between 2001 and 2005, inclusively. Four groups were formed: control; diabetic; positive smoking history; and diabetic and positive smoking history. Multivariate analysis was used to analyse the likelihood of developing complications with a history of diabetes and/or smoking. Our findings indicate that diabetes was significantly associated with an increased risk of developing complications. Patients in the diabetic groups were also significantly older and had a longer length of stay than the other patients ($p < 0.05$ for all significant findings). We conclude that diabetes does increase the risk of poor outcome following lumbar spinal surgery. However, we found no association between a positive smoking history and an increased rate of poor outcome.

1. Introduction

Smoking has been regarded as an independant risk factor for complications after surgery. It is associated with impaired tissue healing and an increased risk of pulmonary and cardiovascular complications after surgery.[1,2] With respect to spinal surgery, smoking has been demonstrated to increase the risk of lumbar disc degeneration, inhibit lumbar spinal fusion, and increase the risk of lumbar disc herniation. Smoking cessation, however, is associated with improved healing of spinal fusion compared to continued smoking. A study by Sanden et al. compared the surgical outcome of smoking and non-smoking patients who underwent lumbar decompression surgery after 2 years of follow-up. They found that although there were improvements in both groups, the smoking group showed less improvement in the form of higher analgesic use, poorer walking ability, and higher dissatisfaction with the surgery.[2]

The findings of Glassman et al. drew a similar conclusion with the non-union rate of spinal fusion being higher in smokers, lower in patients who ceased smoking, and even lower in patients who did not smoke.[3] This is contradicted by Kim et al. who found no correlation between smoking history and increased risk of poor outcome.[2,4] Andersen et al. found that smoking cessation decreased the risk of non-union in spinal fusion and stated that smoking had a negative effect on spinal fusion.[5] Another study by Hansraj et al. found no statistically significant association between smoking and the outcome of decompressive surgery for lumbar spinal stenosis.[6] Delgado-Rodriguez et al. found no relationship between current smokers and risk of surgical site infection (SSI),[7] whereas the results from Moller et al. indicated that smoking is one of the single most important risk factors for the development of wound complications such as impaired wound healing and SSI.[1] Other findings in the literature agree with the conclusions of Moller et al. in that smoking is a risk factor for the development of SSI.[4,8–14]

Diabetes mellitus is a chronic systemic disease that may damage small nerves and blood vessels. It can lead to a poor surgical outcome via impaired wound healing, due to local tissue ischaemia caused by damages to the microvasculature. Diabetes is also a known independant risk factor for SSI, and has been associated with increased infection rates.[4,8–14] Kim et al. suggested that diabetic patients have a higher risk of poor outcome, with neurological damage such as infarcts, demyelination, atrophy, and softening of the posterior spinal cord caused directly by diabetes, which cannot be resolved by decompression surgery.[4]

Kim et al. also suggested that diabetes and smoking have a synergistic effect that can adversely affect the outcome after cervical laminoplasties (odds ratio [OR] of 4.01 for patients positive for diabetes and smoking *versus* 2.92 for patients with only diabetes)[4] However, Chen et al. found that diabetes is a definite risk factor for SSI after posterior spinal instrumentation whereas other variables such as smoking, age, sex, body mass index, estimated blood loss, and surgery time were not factors for the development of SSI.[10]

This study aimed to examine a relatively large number of patients who underwent spinal surgery at the Royal Melbourne Hospital,

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Melbourne, Australia, between 2001 and 2005, looking specifically at lumbar spinal surgery, to assess the effects of smoking and diabetes on the surgical outcome. It was hypothesised that patients with diabetes and/or a positive smoking history would have a higher rate of poor surgical outcome when compared to a control group.

2. Methodology

2.1. Study design

A retrospective cohort study which looked at distinctive and separate cohorts of patients who underwent lumbar spinal surgery at the Royal Melbourne Hospital between 2001 and 2005 was conducted. Ethics approval was granted by the Royal Melbourne Hospital Ethics Committee.

2.2. Patient inclusion criteria

Potential participants were identified by searching the electronic medical record database using procedure codes specific to lumbar spinal surgery and diagnosis codes specific to conditions that use lumbar spinal surgery as treatment. Examples of these conditions include lumbar canal stenosis, prolapsed discs in the lumbar region, and thoracolumbar scoliosis. We defined two broad categories of spinal surgery – decompression and spinal fusion. Decompression surgery included any combination of discectomy and/or laminectomy without fusion. Spinal fusion included fusion of any amount of levels with or without deformity and instrumentation. Only patients with a minimum follow-up period of 1 year were included. Each patient's diabetic and smoking history, if any, was noted. We obtained the records of 977 patients. We excluded 75 patients whose follow-up was incomplete, resulting in 902 patients being enrolled in this project, from which four cohorts were formed: diabetic patients without a positive smoking history; non-diabetic patients with a positive smoking history; diabetic patients with a positive smoking history; and a control group, i.e. patients who were neither diabetic nor had a positive smoking history.

3. Data analysis

The relevant information was extracted from the electronic medical records and clinical notes and edited into an Excel (Microsoft, Redmond, WA, USA) database created for the project. The data were analysed to compare overall outcomes and the rate of good and poor outcomes between the cohorts. With respect to patients who developed a poor outcome, each individual event was analysed to determine its significance and relation to the relevant exposure of diabetes, smoking, or both.

All patients who experienced poor surgical outcome, i.e. complications aside from routine surgical complications, were recorded and the exact nature of those complications were verified by examining the clinical notes and handwritten medical records of the respective patients. The various outcomes were arranged into three main groups to allow for more accurate statistical analysis. The three groups used were:

1. Infectious complications which included abscess formation, cellulitis, gangrene, intravenous line site infection, pneumonia, osteomyelitis, sepsis, stomatitis, urinary tract infection, wound discharge, and wound infection.
2. Cardiovascular complications which included atrial fibrillation, angina, bradycardia, carotid dissection, left ventricular failure, myocardial infarction, pleural effusion, pulmonary embolism, stroke/transient ischaemic attack, supraventricular tachycardia, and syncope.
3. Other complications which included acute post-haemorrhagic anaemia, atelectasis (>2 weeks postoperative), hyperkalaemia, hypernatraemia, hypokalaemia, hyponatraemia, postoperative intestinal obstruction, urine retention, and wound pain (>6 months postoperative).

3.1. Statistical analysis

All statistical analyses were performed using Stata 10 (StataCorp, College Station, TX, USA). Descriptive statistics outlined the variables used in this study. All categorical variables were analysed using Fisher's exact test and continuous, non-normally distributed data (including length of stay (LOS), age) were analysed using the Kruskal–Wallis test. Multivariate logistic regression analysis was performed to examine and predict the factors significantly associated with poor outcome (i.e. infections and all other complications). All multivariate analyses were conducted after adjusting for variables such as age, sex, diabetes/smoking status, comorbidities, and type of surgery. For all comparisons and regressions, statistical significance was assigned at the $p < 0.05$ level.

4. Results

A total of 902 patients underwent lumbar spinal surgery at the Royal Melbourne Hospital between 2001 and 2005, inclusive (Suppl. Table 1). Details of the patient populations in each group are shown in Table 1. Of the 902 patients, 115 (12.75%) patients had a diagnosis of either insulin or non-insulin-dependent diabetes and 383 (42.46%) patients had a positive smoking history. The 40 (4.43%) patients who were both diabetic and had a positive smoking history were placed in a separate group, resulting in 75 (8.31%) patients in the diabetic group, 343 (38.03%) patients in the positive smoking history group and 444 (49.22%) patients in the control group.

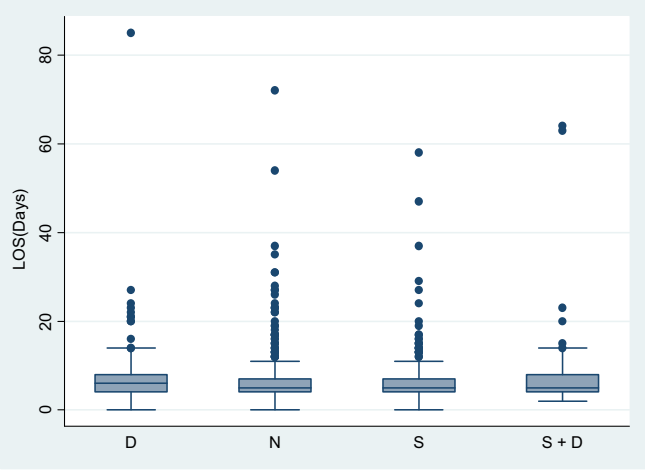
The average patient age was 55 ± 17.7 years (mean ± standard deviation), with the mean age being significantly higher in those who had diabetes. The average age of patients in the diabetic group was 68 ± 9.5 years and 65 ± 10.3 years in the diabetic and positive smoking history group. Patients in the two other groups were younger with the average age of the control group being 54 ± 19 years and the positive smoking history group being 52 ± 16.4 years ($p = 0.001$). The median LOS was 5 days (interquartile range, 3 days) with significant difference between the patient groups ($p = 0.010$; Fig. 1).

Patients in both the diabetic and diabetic and positive smoking history groups had a higher risk of complications compared to those with a positive history of smoking only and the controls (Table 2). Patients who underwent spinal fusion procedures were observed to have higher rates of all types of complications than those who underwent procedures for decompression surgery ($p = 0.002$ and $p = 0.003$, respectively; Table 3).

Multivariate logistic regression analysis was used to assess patient age, diabetes, and positive smoking history as independent variables (Table 4). Diabetes was found to be an independent risk factor for an increased rate of development of infectious

Table 1
Group characteristics of patients who underwent lumbar spinal surgery

Group	n	Percentage
Diabetic	75	8.31
Positive smoking history	343	38.03
Diabetic and positive smoking history	40	4.43
Control	444	49.22
Total	902	100.00



D = diabetic, LOS = length of stay, N = control, S = positive smoking history.

Fig. 1. Box plot of length of stay by condition in lumbar spinal surgery patients.

Table 4
Multivariate logistic regression analysis of the effect of variables on the development of complications in lumbar spinal surgery patients

	Odds ratio (95% CI)	*p* value
Single complication		
Age (years)	1.02 (1.01–1.03)	<0.001
Diabetes	1.77 (1.17–2.68)	0.007
Positive smoking history	1.01 (0.75–1.37)	0.942
Multiple complications		
Age (years)	1.02 (1.00–1.03)	0.115
Diabetes	2.54 (1.28–5.04)	0.008
Positive smoking history	0.88 (0.48–1.63)	0.693
Infectious complications		
Age (years)	1.02 (1.00–1.04)	0.011
Diabetes	2.10 (1.15–3.83)	0.015
Positive smoking history	0.69 (0.41–1.18)	0.174
Cardiovascular complications		
Age (years)	1.02 (1.00–1.04)	0.018
Diabetes	2.25 (1.17–4.32)	0.015
Positive smoking history	0.96 (0.54–1.69)	0.876
Other complications		
Age (years)	1.01 (1.00–1.02)	0.023
Diabetes	1.21 (0.74–1.97)	0.453
Positive smoking history	1.10 (0.78–1.56)	0.585

CI = confidence interval.

complications (OR = 2.10, $p = 0.015$), cardiovascular complications (OR = 2.25, $p = 0.015$), a single complication (OR = 1.77, $p = 0.007$), and multiple complications (OR 2.54, $p = 0.008$). Patient age was found to be a significant predictor for the development of infectious complications (OR = 1.02, $p = 0.011$), cardiovascular complications (OR = 1.02, $p = 0.018$), other complications (OR = 1.01, $p = 0.023$), and single complications (OR = 1.02, $p < 0.001$). A positive smoking history did not increase the risk of developing any form of complications.

5. Discussion

In our patient population, the overall rate of complication development was 27.83%, with 251 of 902 patients developing at least a single complication following lumbar spinal surgery. The overall rate of developing multiple complications was 5.43% (49/902). Patients who underwent spinal fusion procedures had an overall rate of complication development of 39.09% (77/197) compared to patients who underwent decompression surgery without fusion, with an overall rate of 24.68% (174/705). Patients in the spinal fusion group had higher rates of all types of complications. This is not unexpected as it has been documented that the rate of complication or adverse outcome development is higher in spinal fusion surgery, possibly due to longer operative times, more extensive dissections, and instrumentation usage.[17,18]

In univariate analysis, the complication rates varied among the subgroups, with the groups containing diabetic patients having a

Table 2
Proportion of lumbar spinal surgery patients that developed complications in each group

	Control n = 444		Diabetic n = 75		Positive smoking history n = 343		Diabetic and positive smoking history n = 40		Total n = 902	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Total complications	115	25.90	32	42.67	87	25.36	17	42.50	251	27.83
Single	93	20.95	24	32.00	75	21.87	11	27.50	202	22.39
Multiple	22	4.95	8	10.67	12	3.49	6	15.00	49	5.43
Infectious complications	35	7.88	12	16.00	21	6.12	4	10.00	72	7.98
Cardiovascular complications	25	5.63	8	10.67	14	4.08	7	17.50	54	5.99
Other complications	74	16.67	17	22.67	62	18.08	9	22.50	162	17.96

Table 3
Proportion of lumbar spinal surgery patients that developed complications in each surgical group

	Spinal fusion n = 197		Decompression n = 705		Total n = 902	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Total complications	77	39.09	174	24.68	251	27.83
Single	56	28.43	146	20.71	202	22.39
Multiple	21	10.66	28	3.97	49	5.43
Infectious complications	30	15.23	42	5.96	72	7.98
Cardiovascular complications	16	8.12	38	5.39	54	5.99
Other complications	47	23.86	115	16.31	162	17.96

higher rate of developing a single complication ($p = 0.002$) and multiple complications ($p = 0.003$). Multivariate analysis supports these results for both the development of single complications (OR = 1.77, $p = 0.007$) and multiple complications (OR = 2.54, $p = 0.008$). This is consistent with the literature in that diabetes is a risk factor for the development of complications or adverse outcomes.[13,14]

Diabetes was associated with an increased risk of developing infectious complications as defined in this study (OR = 2.10, $p = 0.015$). These findings are supported by the literature, with the increased rate of infections and their sequelae in patients with diabetes being well-documented.[1,4–10] Impaired wound healing due to poor microvascularisation, tissue ischaemia, and a lack of platelet-derived growth factors has been proposed as one of the main causative factors. The immunocompromised state of diabetic patients due to poor circulation of antibiotics and impaired granuloctye function has also been cited as a cause for these increased infection rates.[4,5,10,13]

Diabetes was also an independant risk factor for the development of cardiovascular complications as defined in this study (OR = 2.25, $p = 0.015$). Diabetes is a conventional risk factor for the development of cardiovascular disease, stroke, and hypertension, and is associated with a marked increased risk of atherosclerotic vascular disorders, including coronary, cerebrovascular, and peripheral artery disease.[15,16]

We found that diabetes was not a significant risk factor for the development of other complications, such as acute post-haemorrhagic anaemia, atelectasis (>2 weeks postoperative), hyperkalaemia, hypernatraemia, hypokalaemia, hyponatraemia, postoperative intestinal obstruction, urine retention, and wound pain (>6 months postoperative).

The diabetic patients were significantly older than the non-diabetic patients ($p = 0.001$) and had a longer LOS ($p = 0.010$). Patient age was found in multivariate analysis to be a significant independant predictor for the development of single complications ($p < 0.001$), infectious complications ($p = 0.011$), cardiovascular complications ($p = 0.018$), and other complications ($p = 0.023$). This is well-documented with the literature citing that increasing patient age increases the risk of poor outcome.[1,4–10] However, we found that age was not a significant predictor for the development of multiple complications. To our knowledge, no previous study has reported this finding.

We believe that the higher complication rate seen in the diabetic patients is due to a cumulative effect of increasing age and diabetes, which as discussed above were both found to be independant risk factors in multivariate analysis. As the retrospective nature of this study prevented the patients in each cohort from being age-matched, it is difficult to determine exactly what proportion of the increased complication rate is due to diabetes and increasing age respectively. However, a study conducted by Arinzon et al. compared the outcomes of decompression surgery in the lumbar spine between 62 elderly diabetic patients with an age and sex matched control group. It found that the surgical outcomes of the diabetic patients were less beneficial than the non-diabetic patients in terms of symptom relief, patient satisfaction, basic activities of daily living functions, and rate of complications.[15] This further supports our finding that diabetes increases the rate of adverse outcomes independant of patient age.

Browne et al. demonstrated that diabetes was significantly associated with SSI, need for transfusion, and pneumonia in a study of 197,461 patients who underwent lumbar spinal fusion. The high sample size obtained from a nationwide database over a period of 15 years allowed for multivariate analysis and the determination of diabetes as an independant predictor of adverse outcome.[16]

Schimmer et al. found that the risk of deep SSI after spinal fusion surgery was almost six times higher in patients with diabetes, and more than two times higher in smokers, further suggesting that smoking and diabetes are risk factors for poor outcome.[13] Another study by Veeravagu et al. conducted on 24,774 patients who underwent spinal surgery (decompression, fusion, or instrumentation) to determine the risk factors for postoperative wound infection suggested that insulin-dependent diabetes was associated with a 1.5–fold increased risk for infection, mainly because diabetic patients are more susceptible due to their immunocompromised state, poor vascularisation, and delayed wound healing. Current smoking was also associated with a higher risk of wound infection. These results are consistent with other findings in the literature.[7,9,11,14]

The proportion of patients with a positive smoking history who developed single and multiple complications was identical to that of the control group, implying that a positive smoking history does not increase the rate of development of complications. These results were supported by multivariate logistic regression analysis, which indicated that a positive smoking history was not a significant risk factor for the development of any form of complications following lumbar spinal surgery. These findings are consistent with that of some of the literature,[2,4,6,11,18] but contradict other findings which state that smoking increases the rate of development of poor outcome.[1,3,5–7,12,17]

6. Limitations

This study's main limitation was its retrospective nature. All of the clinical patient information was obtained through review of clinical notes. Unfortunately, not all physicians input the same degree of detail in the medical records, which may result in incomplete clinical information. However, since the size of the cohort was relatively large, we had enough power to accommodate the data and overcome some of these deficiencies.

Electronic coding databases are also subject to error based on incorrect or absent coding of data. Like the physicians' clinical notes, the degree of detail in the coding is subjective to the person entering the data and may result in incomplete or inaccurate clinical information. To the best of our knowledge, the data examined has so far been accurate, but certain complications noted in the clinical notes may not have been coded into the electronic medical records due to changing policies regarding coding detail over the period investigated.

There is also potential recording bias in the medical records, as physicians are more likely to include a diagnosis of diabetes or smoking in patients who have experienced complications. Also, a number of noteworthy factors were not looked at in detail due to the medical records not containing details regarding the severity of the relevant condition or diagnosis. These factors include level of glycaemic control, duration of diabetes, duration and frequency of smoking, and measure of patient satisfaction post-surgery. Finally, the exact spinal level on which the procedure was performed was not noted in the records, as the spinal region was used instead.

7. Conclusions

We conclude that diabetes independently increases the rate of poor outcome following lumbar spinal surgery. Diabetic patients had a significantly higher rate of developing single and multiple complications, especially those of the infectious and cardiovascular nature as defined in this study. A positive smoking history was not associated with a higher rate of poor outcome following lumbar spinal surgery, whether as an independant variable or as a co-dependent variable with diabetes.

Conflicts of interest/disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

Appendix A. Supplementary Material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jocn.2013.01.021.

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