

# Mortality and Morbidity in Dialysis-Dependent Patients Undergoing Spinal Surgery

## Analysis of a National Administrative Database in Japan

Hiroataka Chikuda, MD, PhD, Hideo Yasunaga, MD, PhD, Hiromasa Horiguchi, PhD, Katsushi Takeshita, MD, PhD, Hiroshi Kawaguchi, MD, PhD, Shinya Matsuda, MD, PhD, and Kozo Nakamura, MD, PhD

*Investigation performed at the Department of Orthopaedic Surgery, the University of Tokyo, Tokyo, Japan*

**Background:** The impact of dialysis dependence on perioperative risks following spinal surgery is not fully understood. The purposes of the present study were to determine the perioperative risks in dialysis-dependent patients treated with spinal surgery and to examine whether the presence of destructive spondyloarthropathy further increases perioperative risks.

**Methods:** We examined abstracted data from the Diagnosis Procedure Combination database in a retrospective analysis of a nationally representative inpatient database. The survey of the database is conducted annually for a six-month period between July 1 and December 31. The data from 2007 and 2008 were used for this study. We included all patients who had undergone any combination of laminectomy, laminoplasty, discectomy, and/or spinal arthrodesis. For analysis, dialysis-dependent patients were further classified into subgroups with or without destructive spondyloarthropathy.

**Results:** We identified 51,648 eligible patients (30,743 men and 20,905 women; mean age, sixty-two years), including 869 (1.7%) who were dialysis-dependent. Of the latter, ninety-five had destructive spondyloarthropathy. Overall in-hospital mortality was 0.41%. Dialysis-dependent patients had a significantly higher in-hospital mortality rate than non-dialysis-dependent patients. After adjustment, dialysis-dependent patients remained at a tenfold higher risk for in-hospital death. Dialysis-dependent patients were also at significantly greater risk for postoperative major complications. The rate of complications in dialysis-dependent patients with destructive spondyloarthropathy was 65% higher than that in those without destructive spondyloarthropathy, but this difference did not reach significance.

**Conclusions:** Dialysis-dependent patients had a tenfold higher risk of in-hospital death than did non-dialysis-dependent patients. Dialysis-dependent patients were also more likely to have major complications such as cardiac events, sepsis, and respiratory complications. Our data also indicate that the presence of destructive spondyloarthropathy is associated with a higher rate of postoperative complications in dialysis-dependent patients.

**Level of Evidence:** Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

The number of patients with end-stage renal disease requiring chronic hemodialysis continues to rise steadily, having reached 1.2 million in the world by 2004<sup>1</sup>. Despite recent advances in perioperative management and surgical techniques, spinal surgery in dialysis-dependent patients remains a clinical challenge. Patients on chronic hemodialysis often present with multiple comorbidities, including anemia, cardiovascular disease, and diabetes mellitus. Many of these

patients have additional problems, such as suboptimal bone quality and extensive adhesions surrounding neural elements, which further complicate spinal surgery.

Moreover, chronic hemodialysis in itself can cause serious spinal pathology—destructive spondyloarthropathy, which is characterized by disc space narrowing with erosions of the adjacent end plates and minimal osteophyte formation<sup>2-4</sup>. Destructive spondyloarthropathy predominantly affects the

**Disclosure:** None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

cervical spine, with the reported prevalence ranging from 5% to 25.3%<sup>5,6</sup>. Destructive spondyloarthropathy may progress rapidly, resulting in severe spinal instability and neurological compromise. Treatment of symptomatic destructive spondyloarthropathy often requires complex spinal surgery such as multilevel arthrodesis. A high rate of complications has been reported in this subgroup of dialysis-dependent patients in prior case series<sup>2,4,7-10</sup>.

Despite the potentially devastating consequences of chronic hemodialysis, the impact of dialysis dependence on the perioperative risks of contemporary spinal surgery is not fully understood. Published studies, which largely consist of single-institution case series<sup>2,4,7-11</sup>, vary greatly with respect to reported incidences of in-hospital death and postoperative complications, primarily because of small sample sizes and bias in selection of the study population. To our knowledge, no large study has been performed to investigate the outcomes of spinal surgery in patients on chronic hemodialysis. Although information about the risks associated with various treatment options is crucial for clinical decision-making, there is a lack of such information for dialysis-dependent patients undergoing spinal surgery.

The purposes of this study were to determine the perioperative risks in patients on chronic hemodialysis who undergo spinal surgery and to examine whether the presence of destructive spondyloarthropathy further increases perioperative risks in dialysis-dependent patients. We abstracted data on over 50,000 patients who had undergone spinal surgery from a nationally representative inpatient database in Japan and evaluated the results of spinal surgery in dialysis-dependent patients.

## Materials and Methods

### Diagnosis Procedure Combination (DPC) Database

The DPC database is a nationally representative database in Japan consisting of discharge abstract and administrative claim data<sup>12-14</sup>. The DPC hospitals are surveyed between July 1 and December 31 each year by the DPC Research Group, in collaboration with the government. In the current study, we used data obtained by this annual survey in 2007 and 2008. In 2007-2008, data from about 5.9 million inpatients were added to the database, which represents approximately 45% of all acute-care inpatient hospitalizations in Japan. Researchers use the DPC database to identify, track, and analyze national trends in health-care utilization, access, quality, outcomes, and costs. The database includes the following data: patient age and sex; diagnoses, comorbidities at admission, and complications after admission recorded according to the International Classification of Diseases, Tenth Revision (ICD-10) codes and text data in the Japanese language; procedures coded with the Japanese original codes; durations of anesthesia; blood transfusions; lengths of hospital stay, and in-hospital deaths.

The anonymous nature of the data allowed the requirement for informed consent to be waived. Study approval was obtained from the institutional review board.

### Patients

We included all patients who had any combination of laminectomy, laminoplasty, discectomy, and/or spinal arthrodesis. The following variables were abstracted from the DPC database: age, sex, primary diagnosis, preoperative comorbidities, surgical site (cervical, thoracic, or lumbar spine), duration of anesthesia, use of blood transfusion, length of hospital stay, and postoperative adverse events. The primary diagnoses included spinal canal stenosis (M480), spondylosis (M47), disc herniation (M50, M51), spondylolisthesis (M430, M431), and vertebral fracture (S12, S22, S32, T08). Preoperative comorbidities included hypertension

(I10-I15), diabetes mellitus (E10-E14), history of cardiac diseases (ischemic heart disease [I20-I25] or other forms of heart disease [I30-I52]), history of cerebrovascular disease (I60-I69), chronic lung disease (J40-J47), and hepatic cirrhosis (K74). Postoperative adverse events included surgical site infection (T793, T814), sepsis (A40, A41), pulmonary embolism (I26), respiratory complications (pneumonia [J12-J18], postprocedural respiratory disorders [J95], or respiratory failure [J96]), cardiac events (acute coronary events [I21-I24] or heart failure [I50]), stroke (cerebral infarction or hemorrhage [I60-I64]), and in-hospital death. We focused on these major complications because they were more consistently coded than were minor complications. For analysis, we divided the patients into three groups: patients not on chronic hemodialysis (non-dialysis-dependent patients), dialysis-dependent patients without destructive spondyloarthropathy, and dialysis-dependent patients with destructive spondyloarthropathy.

### Statistical Analysis

We used chi-square tests, t tests, or analyses of variance as appropriate to perform univariate analyses comparing patient characteristics and outcomes between subgroups. Logistic regression analyses with adjustment for patient characteristics were performed to analyze the concurrent effects of various factors on the occurrence of in-hospital deaths and postoperative complications. In the regressions, these events were modeled as functions of age, sex, dialysis dependence, surgical site, spinal arthrodesis, duration of anesthesia, and preexisting comorbidities.

The threshold for significance was a p value <0.05.

### Source of Funding

This study was funded by Grants-in-Aid for Research on Policy Planning and Evaluation from the Ministry of Health, Labour and Welfare, Japan.

## Results

We identified 51,648 eligible patients (30,743 men and 20,905 women; mean age, sixty-two years) from 774 hospitals, including eighty-two teaching hospitals and 692 non-teaching hospitals (Table I). Among the patients, 869 (1.7%) were receiving maintenance hemodialysis. Of these, ninety-five (10.9%) had destructive spondyloarthropathy. With regard to the primary diagnoses, 19,844 patients (38.4%) had spinal canal stenosis; 10,224 (19.8%), disc herniation; 8542 (16.5%), spondylosis; 4893 (9.5%), spondylolisthesis; 3268 (6.3%), vertebral fracture; 1820 (3.5%), ossification of the posterior longitudinal ligament; 729 (1.4%), neoplasm; 356 (0.7%), infective spondylopathy; 348 (0.7%), scoliosis; and 1624 (3.1%), other spinal disease. Laminectomy was performed in 10,177 patients (19.7%); laminoplasty, in 16,237 (31.4%); discectomy, in 8822 (17.1%); and spinal arthrodesis, in 16,412 (31.8%). The site of surgery was the cervical spine in 13,157 patients (25.5%), the thoracic spine in 1086 (2.1%), and the lumbar spine in 34,143 (66.1%); data were not available for the remaining 3262 cases (6.3%).

Dialysis-dependent patients were more likely to have a history of systemic diseases such as cardiac disease, hepatic cirrhosis, hypertension, and diabetes mellitus. The proportion of patients who underwent spinal arthrodesis was significantly higher in the dialysis-dependent group (31.6% in the non-dialysis-dependent group versus 43.3% in the dialysis-dependent group;  $p < 0.001$ ); this was especially the case among those with destructive spondyloarthropathy. Dialysis-dependent patients were also more likely to require blood transfusion (12.0% in the non-dialysis-dependent group versus 21.6% in the dialysis-dependent group;  $p < 0.001$ ) and a longer duration of anesthesia

TABLE I Characteristics of the Study Population According to Dialysis Status \*

	No Hemodialysis (N = 50,779)	Hemodialysis			P Value
		Total (N = 869)	Without Destructive Spondyloarthropathy (N = 774)	With Destructive Spondyloarthropathy (N = 95)	
Teaching hospitals	10,347 (20.4%)	252 (29.0%)	207	45	<0.001
Sex (males)	30,201 (59.5%)	542 (62.4%)	481	61	0.085
Age (mean ± SD) (yr)	62.3 ± 15.6	64.3 ± 8.2	64.7 ± 8.2	60.9 ± 7.6	<0.001
Preoperative comorbidities					
History of cardiac disease	2597 (5.1%)	126 (14.5%)	112	14	<0.001
History of cerebrovascular disease	515 (1.0%)	6 (0.7%)	6	0	0.344
Chronic lung disease	988 (1.9%)	16 (1.8%)	16	0	0.825
Liver cirrhosis	99 (0.2%)	6 (0.7%)	5	1	0.001
Hypertension	8180 (16.1%)	224 (25.8%)	198	26	<0.001
Diabetes mellitus	6252 (12.3%)	166 (19.1%)	151	15	<0.001
Site of surgery					
Cervical	12,839 (25.3%)	318 (36.6%)	268	50	<0.001
Thoracic	1071 (2.1%)	15 (1.7%)	11	4	
Lumbar	33,656 (66.3%)	487 (56.0%)	453	34	
Unspecified	3213 (6.3%)	49 (5.6%)	42	7	
Spinal arthrodesis	16,036 (31.6%)	376 (43.3%)	296	80	<0.001
Blood transfusion	6113 (12.0%)	188 (21.6%)	154	34	<0.001
Duration of anesthesia (median [IQR]) (min)	125 (35-229)	145 (49-265)	145 (48-258)	148 (55-330)	<0.001

\*SD = standard deviation, and IQR = interquartile range.

(median, 125 minutes in the non-dialysis-dependent group versus 145 minutes in the dialysis-dependent group;  $p < 0.001$ ). Length of hospital stay averaged 29.6 days for the non-dialysis-dependent patients, 38.8 days for the dialysis-dependent patients without destructive spondyloarthropathy, and 46.2 days for those with destructive spondyloarthropathy ( $p < 0.001$ ).

The overall rate of in-hospital deaths following spinal surgery was 0.41% (Table II). The dialysis-dependent patients had a significantly higher in-hospital mortality rate (3.57%) than the non-dialysis-dependent patients (0.35%) ( $p < 0.001$ ). The most common postoperative complications were surgical site infections (1.69%), followed by cardiac events (0.94%) and respiratory complications (0.68%). Overall, 1926 (3.73%) of the patients experienced at least one complication. The dialysis-dependent patients also had a significantly higher complication rate than non-dialysis-dependent patients (9.55% versus 3.63%;  $p < 0.001$ ). Of note, the complication rate for dialysis-dependent patients with destructive spondyloarthropathy was 65% higher than the rate for those without destructive spondyloarthropathy (14.7% versus 8.91%), but this difference did not reach significance ( $p = 0.068$ ).

We performed logistic regression analyses for in-hospital mortality and postoperative complication rates (Table III).

After adjustment, dialysis-dependent patients remained at a tenfold higher risk for in-hospital death (odds ratio, 9.81; 95% confidence interval, 5.96 to 16.29;  $p < 0.001$ ). Dialysis-dependent patients were also at higher risk for postoperative major complications (odds ratio, 2.43; 95% confidence interval, 1.88 to 3.15;  $p < 0.001$ ). Patients undergoing spinal arthrodesis were significantly more likely to die (odds ratio, 2.66; 95% confidence interval, 1.84 to 3.83;  $p < 0.001$ ) and to experience postoperative complications (odds ratio, 1.45; 95% confidence interval, 1.29 to 1.61;  $p < 0.001$ ). Other factors associated with increases in perioperative mortality and morbidity included surgery on the cervical or thoracic spine, male sex, older age, longer anesthesia time, chronic lung disease, and hepatic cirrhosis.

### Discussion

In this study, we used data from the DPC database, a nationally representative inpatient database in Japan, to compare the rates of in-hospital death and major complications following spinal surgery between dialysis-dependent and non-dialysis-dependent patients. Our study resulted in three major findings. First, patients on chronic hemodialysis had a tenfold higher risk of in-hospital death than non-dialysis-dependent patients following spinal surgery. Second, dialysis-dependent patients were

TABLE II Adverse Outcomes Following Spinal Surgery According to Dialysis Status\*

	All (N = 51,648)			No Hemodialysis (N = 50,779)		
	No.	%	95% CI	No.	%	95% CI
In-hospital death	211	0.41	0.35-0.46	180	0.35	0.30-0.41
Postoperative complications						
At least one complication	1926	3.73	3.57-3.89	1843	3.63	3.47-3.79
Surgical site infection	875	1.69	1.58-1.81	852	1.68	1.57-1.79
Cardiac event	484	0.94	0.85-1.02	458	0.90	0.82-0.98
Respiratory complication	349	0.68	0.61-0.75	332	0.65	0.58-0.72
Sepsis	148	0.29	0.24-0.33	127	0.25	0.21-0.29
Stroke	86	0.17	0.13-0.20	82	0.16	0.13-0.20
Pulmonary embolism	67	0.13	0.10-0.16	66	0.13	0.10-0.16

\*CI = confidence interval.

more likely to have major postoperative complications, such as cardiac events, sepsis, and respiratory complications, than those not receiving dialysis. Lastly, the presence of destructive spondyloarthropathy was associated with a higher rate of postoperative complications in dialysis-dependent patients.

The main strength of our study is the use of a large administrative database. Recently, nationally representative inpatient databases such as the National Inpatient Sample and the DPC database have been increasingly used to assess trends and outcomes of various surgical procedures<sup>12-18</sup>. With a study population of over 50,000 patients, the current analysis is the largest to compare outcomes following spinal surgery in dialysis and non-dialysis-dependent patients, to our knowledge. Use of the large nationally representative database allowed us to evaluate the magnitude of perioperative risks after spinal surgery in dialysis-dependent patients, an assessment that has not been possible in prior studies. In addition, the present study also had enough power to detect differences in the occurrence of adverse events between dialysis and non-dialysis-dependent patients while controlling for confounding variables.

In this study, overall in-hospital mortality following spinal surgery was 0.41%, which is comparable with that reported in prior studies with large databases (0.57% after cervical spondylotic myelopathy<sup>19</sup>, 0.3% after adult scoliosis<sup>20</sup>, and 0.17% after lumbar laminectomy<sup>21</sup>). Hemodialysis dependence significantly increases perioperative risks following contemporary spinal surgery. Of note, dialysis-dependent patients undergoing spinal surgery had a tenfold higher risk of in-hospital death than non-dialysis-dependent patients. The odds ratio of in-hospital death was essentially unchanged after adjustment for other surgical risk factors, indicating that the increased risk among dialysis-dependent patients is largely attributable to the end-stage renal disease itself. Similarly, prior studies in other surgical specialties have demonstrated that dialysis dependence has a substantial negative impact on perioperative mortality and morbidity. Dialysis-dependent patients have a threefold higher

mortality rate following coronary artery bypass surgery<sup>22,23</sup> and a fivefold higher mortality rate following colorectal surgery<sup>24</sup>.

In the current study, we also examined whether destructive spondyloarthropathy has an additional negative impact on the occurrence of postoperative adverse outcomes in dialysis-dependent patients. The prevalence of destructive spondyloarthropathy in our study was 10.9% of the dialysis-dependent patients, which is similar to that reported in prior studies<sup>5,6</sup>. Destructive spondyloarthropathy, a well-known sequela of long-term hemodialysis, can cause serious spinal instability and subsequent neurological compromise due to extensive destruction of intervertebral discs and paravertebral ligaments. Patients with symptomatic destructive spondyloarthropathy often require complex spinal surgery, including multilevel instrumentation, to stabilize the spine. Despite its potentially devastating consequences, there is a relative lack of information about surgical treatment in dialysis-dependent patients with destructive spondyloarthropathy. Abumi et al. reported on sixteen patients with cervical destructive spondyloarthropathy who underwent reconstructive surgery<sup>2</sup>. Most of their patients required circumferential arthrodesis because of marked destructive changes in the cervical spine. In the present study, >80% of the patients with destructive spondyloarthropathy underwent spinal arthrodesis. We found that the presence of destructive spondyloarthropathy was associated with use of blood transfusions and longer anesthesia time, indicating that more complex surgical procedures were performed in this subgroup. The neurological outcomes in the patients in the study by Abumi et al. were mostly favorable; however, they reported two postoperative deaths during the follow-up period. Similarly, other investigators have reported that postoperative death of patients with destructive spondyloarthropathy is not uncommon<sup>4,7,8</sup>. We therefore hypothesized that the presence of destructive spondyloarthropathy itself further increases the risk of postoperative adverse outcomes following spinal surgery. Of note, the complication rate in the patients with destructive spondyloarthropathy

TABLE II (continued)

Hemodialysis						
All (N = 869)			Without Destructive Spondyloarthropathy (N = 774)		With Destructive Spondyloarthropathy (N = 95)	
No.	%	95% CI	No.	No.	P Value	
31	3.57	2.33-4.80	27	4	<0.001	
83	9.55	7.59-11.5	69	14	<0.001	
23	2.65	1.58-3.72	20	3	0.083	
26	2.99	1.86-4.13	20	6	<0.001	
17	1.96	1.03-2.88	13	4	<0.001	
21	2.42	1.39-3.44	19	2	<0.001	
4	0.46	0.01-0.91	4	0	0.051	
1	0.12	0.00-0.34	1	0	0.94	

was 65% higher than that in dialysis-dependent patients without destructive spondyloarthropathy, although this difference did not reach significance. The small number of patients with destructive spondyloarthropathy precluded further statistical analyses, including comparison of in-hospital mor-

tality and multivariate analysis. The higher incidences of in-hospital deaths of, and major complications in, patients with destructive spondyloarthropathy might be attributable to the longer and more complex surgical procedures that are often undertaken in this subgroup.

TABLE III Adjusted Risks of Adverse Outcomes After Spinal Surgery\*

	In-Hospital Mortality			Postoperative Complications		
	OR	95% CI	P Value	OR	95% CI	P Value
Hemodialysis						
No	Reference			Reference		
Yes	9.81	5.96-16.29	<0.001	2.43	1.88-3.15	<0.001
Surgical procedures						
Without spinal fusion	Reference			Reference		
With spinal fusion	2.66	1.84-3.83	<0.001	1.45	1.29-1.61	<0.001
Surgical site						
Lumbar	Reference			Reference		
Cervical	2.23	1.53-3.26	<0.001	1.18	1.06-1.33	0.004
Thoracic	6.01	3.28-11.02	<0.001	1.88	1.44-2.46	<0.001
Sex						
Male	Reference			Reference		
Female	0.55	0.38-0.82	0.003	0.76	0.68-0.85	<0.001
Age (10-yr age increase)	1.94	1.6-2.34	<0.001	1.23	1.18-1.28	<0.001
Duration of anesthesia (hr)	1.09	1.05-1.13	<0.001	1.04	1.02-1.05	<0.001
History of cardiac diseases	1.32	0.76-2.31	0.325	1.99	1.68-2.34	<0.001
History of cerebrovascular disease	1.62	0.5-5.19	0.418	1.66	1.14-2.43	0.009
Chronic lung disease	4.46	2.49-7.96	<0.001	2.36	1.84-3.03	<0.001
Liver cirrhosis	9.61	2.85-32.44	<0.001	3.58	1.88-6.84	<0.001

\*OR = odds ratio, and CI = confidence interval.

Several of the limitations of the present study are inherent to all administrative database studies. First, the DPC database does not provide important clinical data such as duration of hemodialysis, presence of myelopathy, and type of instrumentation used for arthrodesis. Second, the coding has not been directly validated against clinical data, and access to the patients' charts is not possible. While it is unlikely that substantial amounts of miscoding occurred, especially in the case of in-hospital deaths or hemodialysis, certain data could have been underrepresented or misrepresented, creating bias. Lastly, the DPC database does not provide any information after discharge, so complications such as wound infection are likely underrepresented. However, the average length of hospital stay of more than four weeks in the current study is probably sufficient to ensure that the majority of postoperative adverse events were included. Readers may well wonder why the length of hospital stay reported here is so long. According to the Organisation for Economic Co-operation and Development (OECD) health data<sup>25</sup>, the national average length of hospital stay in Japan is 18.8 days, which is much longer than that in the United States (5.5 days). In Japan, hospitals often provide both early postoperative care and subsequent rehabilitation in a single hospitalization. We believe that the difference between Japan and the United States in the length of stay is principally attributable to differences in the health-care systems of the two nations. Despite these limitations, we believe that our study contains valuable information of clinical importance and provides a basis for future research.

In conclusion, patients receiving hemodialysis have a greatly increased risk of mortality and morbidity following spinal surgery. The findings of the present study provide a basis for a better understanding of the perioperative risks following spinal surgery and will permit better clinical decision-making for this medically fragile patient population. ■

Hirotsuka Chikuda, MD, PhD  
Hideo Yasunaga, MD, PhD  
Hiromasa Horiguchi, PhD  
Katsushi Takeshita, MD, PhD  
Hiroshi Kawaguchi, MD, PhD  
Kozo Nakamura, MD, PhD  
Department of Orthopaedic Surgery,  
Faculty of Medicine (H.C., K.T., H.K., and K.N.), and  
Department of Health Management and Policy,  
Graduate School of Medicine (H.Y. and H.H.),  
The University of Tokyo,  
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan.  
E-mail address for H. Chikuda: chikuda-tyk@umin.ac.jp

Shinya Matsuda, MD, PhD  
Department of Preventive Medicine and Community Health,  
University of Occupational and Environmental Health,  
1-1 Iseigaoka, Yahatanishi-ku, Kitakyushu 807-8555, Japan

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