Original article

Outcomes after surgery in patients with previous stroke

C. C. Liao[1,2,3,8], P. Y. Chang[6], C. C. Yeh[7,9], C. J. Hu[3,4], C. H. Wu[3,5] and T. L. Chen[1,2,3]

[1]Department of Anaesthesiology and [2]Health Policy Research Centre, Taipei Medical University Hospital, [3]School of Medicine, Taipei Medical University, and Departments of [4]Neurology and [5]Surgery, Shuang Ho Hospital, Taipei Medical University, Taipei, [6]Department of Eldercare, National Tainan Institute of Nursing, Tainan City, and [7]Department of Surgery, China Medical University Hospital, and [8]School of Chinese Medicine, College of Chinese Medicine, China Medical University, Taichung, Taiwan, and [9]Department of Surgery, University of Illinois, Chicago, Illinois, USA

Correspondence to: Professor T. L. Chen, Department of Anaesthesiology, Taipei Medical University Hospital, 252 Wuxing Street, Taipei 11031, Taiwan. (e-mail: tlc@tmu.edu.tw)

Background: **Limited information is available on the association between a medical history of stroke and postoperative outcomes. This study investigated the outcomes following non-neurological surgery in patients with previous stroke.**

Methods: **Using Taiwan's National Health Insurance Research Database, a nationwide cohort study was conducted of patients who underwent non-neurological surgery between 2008 and 2010 with a medical history of stroke in the 24-month period before operation. Patients who had non-neurological surgeries without previous stroke were selected as controls by the propensity score-matched pair method. Thirty-day postoperative complications and in-hospital mortality were compared between the two groups.**

Results: **Some 1 426 795 adults underwent major inpatient non-neurological surgery, of whom 45 420 had a medical history of previous stroke. Patients with previous stroke who underwent surgery had an increased risk of postoperative pneumonia, septicaemia, acute renal failure, acute myocardial infarction, pulmonary embolism and 30-day in-hospital mortality (adjusted rate ratio (RR) 1·79, 95 per cent c.i. 1·61 to 1·99). Compared with controls, patients with previous stroke due to intracerebral haemorrhage (RR 3·41, 2·97 to 3·91), and those who were treated in intensive care (RR 2·55, 2·24 to 2·90) or underwent neurosurgery (RR 2·49, 2·12 to 2·92), had an increased 30-day in-hospital mortality rate. Postoperative mortality also increased with stroke-related co-morbidities, and with stroke 1–6 months before surgery (RR 3·31, 2·91 to 3·75).**

Conclusion: **Patients with previous stroke had a higher risk of adverse postoperative outcomes; their 30-day in-hospital mortality rate was nearly twice that of patients without previous stroke.**

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Introduction

Although the incidence of stroke has been declining[1], stroke remains a leading cause of acquired disability and death in adults worldwide[2–4]. Risk factors, prevention strategies and genetic biomarkers for stroke have been studied extensively[3]. Rehabilitation, such as physiotherapy, may prevent sequelae after stroke and improve functional status[5]. However, patients with previous stroke still suffer from common sequelae and complications such as dementia, depression, pneumonia, urinary tract infection, decubitus ulcer, hip fracture, traumatic brain injury, epilepsy, dysphagia and constipation[5–8]. Thus, the acute care services for patients with previous stroke have been documented with higher complications and mortality rates[6,7,9].

Studies investigating adverse postoperative events in patients with previous stroke have been limited by small sample sizes[10–12], single type of surgical procedure[10–16], lack of control group[10–19], control groups with no matching[10–19], inadequate adjustment for potential confounding effects[10,14] and single-outcome reporting[10–12,15].

With the use of Taiwan's National Health Insurance Research Database, a population-based cohort study was conducted to investigate the full spectrum of adverse postoperative outcomes, and to analyse the impact of disease severity for patients with previous stroke who underwent major non-neurological surgery.

Methods

Source of data

Reimbursement claims data from Taiwan's National Health Insurance were used in this study. More than 99 per

cent of the 22·6 million residents of Taiwan are enrolled in this system. Taiwan's National Health Research Institutes established a National Health Insurance Research Database to record all inpatient and outpatient medical services of beneficiaries, including patient demographics, primary and secondary diagnoses of diseases, procedures, prescriptions and medical expenditures[5,20–25]. The accuracy of major diagnostic codes in the National Health Insurance Research Database has been validated in a previous study[26].

Ethical approval

Insurance reimbursement claims from Taiwan's National Health Insurance Research Database are maintained by the National Health Research Institutes and are available for public access. To protect personal privacy, the electronic database was de-identified, with patient identifications scrambled for further public access for research. According to National Health Research Institutes regulations, informed consent is not required owing to decoded and scrambled patient identification. This study was evaluated and approved by the National Health Research Institutes and conducted in accordance with the Helsinki Declaration.

Study design

From the medical claims of the National Health Insurance Research Database, adults aged 20 years and above who underwent major inpatient non-neurological surgery from 2008 to 2010 were identified. Patients who had major non-neurological surgery, defined as surgery requiring general, epidural or spinal anaesthesia and hospitalization for more than 1 day, and who had a history of stroke within the 24-month interval before surgery, were included in the study. The criteria for identifying patients with a medical history of stroke have been defined in previous studies[5,20,21].

The present study used the propensity score-matched pair method to select control patients with no previous stroke. The propensity score was estimated using a logistic regression model including co-variables generally considered to be associated with adverse events after surgery. The selected matching factors were based on previous surgical studies[22–25].

Definitions

Information on operation in teaching hospital and low-income status was identified according to Bureau of National Health Insurance regulations. Patients with low income were defined as those qualifying for waived medical co-payment as certified by the Bureau of National Health Insurance. The age of the study population was defined as that at index operation. According to the Clinical Modification of ICD-9, stroke was defined as ICD-9-CM 430–438 in the present study. Co-existing medical conditions included hypertension, diabetes, mental health disorder, chronic obstructive pulmonary disease, ischaemic heart disease, hyperlipidaemia and liver cirrhosis, diagnosed in the 24-month interval before surgery (*Table S1*,

Table 1 Characteristics of the cohort of patients with and without stroke in the 24-month period before surgery

	No stroke ($n = 1\,381\,375$)	Stroke ($n = 45\,420$)	P†
Age (years)			< 0·001
20–29	218 284 (15·8)	591 (1·3)	
30–39	296 777 (21·5)	1022 (2·3)	
40–49	264 382 (19·1)	2602 (5·7)	
50–59	248 939 (18·0)	6457 (14·2)	
60–69	166 512 (12·1)	9333 (20·5)	
≥ 70	186 481 (13·5)	25 415 (56·0)	
Sex ratio (F : M)	785 615 : 595 760	18 480 : 26 940	< 0·001
Operation in teaching hospital	1 174 886 (85·0)	41 068 (90·4)	< 0·001
Low income status*	27 810 (2·0)	1542 (3·4)	< 0·001
Type of surgery			< 0·001
Skin	55 583 (4·0)	2585 (5·7)	
Breast	34 755 (2·5)	376 (0·8)	
Musculoskeletal	393 643 (28·5)	17 199 (37·9)	
Respiratory	74 484 (5·4)	2954 (6·5)	
Cardiovascular	30 940 (2·2)	4021 (8·9)	
Digestive	289 747 (21·0)	9600 (21·1)	
Kidney, ureter, bladder	108 759 (7·9)	4970 (10·9)	
Delivery, CS, abortion	178 778 (12·9)	157 (0·3)	
Eye	14 761 (1·1)	634 (1·4)	
Other	199 925 (14·5)	2924 (6·4)	
Type of anaesthesia			< 0·001
General	895 034 (64·8)	30 842 (67·9)	
Epidural or spinal	486 341 (35·2)	14 578 (32·1)	
Co-existing medical conditions			
Hypertension	227 733 (16·5)	20 156 (44·4)	< 0·001
Diabetes	119 808 (8·7)	12 999 (28·6)	< 0·001
Mental health disorder	174 339 (12·6)	11 521 (25·4)	< 0·001
COPD	132 181 (9·6)	9413 (20·7)	< 0·001
Ischaemic heart disease	58 576 (4·2)	7223 (15·9)	< 0·001
Hyperlipidaemia	71 250 (5·2)	2947 (6·5)	< 0·001
Renal dialysis	15 394 (1·1)	1927 (4·2)	< 0·001
Liver cirrhosis	36 868 (2·7)	1552 (3·4)	< 0·001

Values in parentheses are percentages. *Defined as patients qualifying for waived medical co-payment as certified by the Bureau of National Health Insurance. CS; caesarean section; COPD, chronic obstructive pulmonary disease. †χ^2 test.

Table 2 Adverse postoperative events in patients with and without preoperative stroke before and after propensity score matching

	No stroke*	Stroke*	Adjusted rate ratio‡
Before propensity score matching			
Postop. complications	*n* = 1 381 375	*n* = 45 420	
Pneumonia	15 442 (1·1)	2365 (5·2)	1·86 (1·77, 1·94)
Septicaemia	46 793 (3·4)	5096 (11·2)	2·14 (2·08, 2·21)
Acute renal failure	7223 (0·5)	1434 (3·2)	2·18 (2·05, 2·31)
Acute myocardial infarction	2521 (0·2)	487 (1·1)	1·47 (1·33, 1·63)
Deep wound infection	7434 (0·5)	282 (0·6)	1·04 (0·92, 1·18)
Pulmonary embolism	792 (0·1)	85 (0·2)	1·53 (1·21, 1·93)
Postop. bleeding	7575 (0·5)	358 (0·8)	1·05 (0·94, 1·17)
Any of the above	77 815 (5·6)	8218 (18·1)	1·90 (1·85, 1·94)
30-day in-hospital mortality	5205 (0·4)	956 (2·1)	2·41 (2·24, 2·59)
Prolonged LOS§	260 747 (18·9)	16 911 (37·2)	1·49 (1·46, 1·52)
ICU stay	312 251 (22·6)	26 240 (57·8)	1·77 (1·75, 1·79)
Increased medical expenditure§	268 671 (19·4)	16 328 (35·9)	1·19 (1·17, 1·21)
After propensity score matching			
Postop. complications	*n* = 45 420	*n* = 45 420	
Pneumonia	1223 (2·7)	2365 (5·2)	1·93 (1·80, 2·07)
Septicaemia	2785 (6·1)	5096 (11·2)	1·83 (1·75, 1·92)
Acute renal failure	841 (1·9)	1434 (3·2)	1·71 (1·57, 1·86)
Acute myocardial infarction	372 (0·8)	487 (1·1)	1·31 (1·14, 1·50)
Deep wound infection	285 (0·6)	282 (0·6)	0·99 (0·84, 1·16)
Pulmonary embolism	50 (0·1)	85 (0·2)	1·70 (1·20, 2·41)
Postop. bleeding	361 (0·8)	358 (0·8)	0·99 (0·86, 1·15)
Any of the above	4896 (10·8)	8218 (18·1)	1·68 (1·62, 1·74)
30-day in-hospital mortality	538 (1·2)	956 (2·1)	1·79 (1·61, 1·99)
Prolonged LOS§	7242 (15·9)	10 141 (22·3)	1·40 (1·36, 1·44)
ICU stay	15 473 (34·1)	19 114 (42·1)	1·24 (1·21, 1·26)
Increased medical expenditure§	8308 (18·3)	9860 (21·7)	1·19 (1·15, 1·22)

*Values are numbers of patients with percentages in parentheses; †values in parentheses are 95 per cent c.i. ‡Adjusted for age, sex, teaching hospital, low income, urbanization, co-existing medical conditions, type of surgery and type of anaesthesia. §Categorized into quartiles; surgical patients who had the highest quartile of length of stay (LOS) or in-hospital medical expenditure were defined as those with increased LOS or increased medical expenditure. ICU, intensive care unit.

supporting information). Renal dialysis was also identified as a co-existing medical condition.

Acute myocardial infarction, acute renal failure, deep wound infection, pneumonia, postoperative bleeding, pulmonary embolism and septicaemia were identified as major postoperative complications occurring within the 30-day period after index surgery; patients diagnosed with these conditions during the 24-month interval before surgery were excluded from analysis. Medical resource utilization, such as length of hospital stay (LOS), admission to the intensive care unit (ICU) within 30 days of the index operation and in-hospital medical expenditure, was analysed. LOS and in-hospital medical expenditure of patients with and without previous stroke who had surgery were categorized into quartiles. Patients in the highest quartile of LOS or in-hospital medical expenditure among the total number of patients undergoing surgery were defined as those with increased LOS or medical expenditure.

To explore the correlation between severity of stroke and adverse postoperative outcomes, types of treatment for stroke, use of medical resources and medical expenditure were analysed. Stroke-related co-morbidities, such as traumatic brain injury, dementia, pneumonia and decubitus ulcer, were also identified as clinical indicators of stroke severity[6–8].

Statistical analysis

To reduce the confounding influence of co-variables, a propensity score was used to match age, sex, low-income status, co-existing medical conditions, operation in teaching hospital, types of surgery and anaesthesia between patients with and without previous stroke. χ^2 tests were used to examine differences in parameters between patients undergoing surgery with and without previous stroke.

Adjusted rate ratios (RRs) with 95 per cent c.i. for 30-day postoperative complications, in-hospital mortality, prolonged LOS, ICU stay and increased medical expenditure between patients with or without stroke who underwent surgery were analysed with multivariable Poisson regression by including age, sex, low-income status, operation in teaching hospital, preoperative co-existing

medical conditions, and types of surgery and anaesthesia. To assess the impact of stroke severity on 30-day postoperative in-hospital mortality, multivariable Poisson regression was used to control the potential confounders: stroke-related neurosurgery, stroke within 1–6 months before surgery, ICU stay, medical expenditure, traumatic brain injury, dementia, pneumonia and decubitus ulcer. Differences between groups were considered significant when the two-sided *P* value was less than 0·050. Statistical analysis was performed with SAS® version 9.1 (SAS Institute, Cary, North Carolina, USA).

Results

Of 1 426 795 patients who had major non-neurological surgery, 45 420 had experienced a previous stroke. There were significant differences in sociodemographic variables, operation in teaching hospital, types of surgery or anaesthesia, and medical conditions between patients with and without previous stroke who underwent surgery (*Table 1*). However, after propensity score matching there were no significant differences between patients with and without previous stroke ($P = 1{\cdot}000$ for all comparisons) (*Table S2*, supporting information).

Before propensity score matching, previous stroke was associated with postoperative pneumonia, septicaemia, acute renal failure, acute myocardial infarction, pulmonary embolism, any complication, prolonged hospital stay, ICU stay, increased medical expenditure and 30-day in-hospital mortality (*Table 2*). After propensity score matching and multivariable adjustment, patients with previous stroke had a higher risk of postoperative 30-day in-hospital mortality (RR 1·79), prolonged hospital stay (RR 1·40), ICU stay (RR 1·24) and increased medical expenditure (RR 1·19), as well as postoperative complications including pneumonia, septicaemia, acute renal failure, acute myocardial infarction and pulmonary embolism (*Table 2*). Compared with control patients, patients with stroke 1–6 months before surgery had an increased 30-day postoperative in-hospital mortality rate (RR 3·31) (*Table 3*). Patients with previous stroke and low income had an increased 30-day postoperative in-hospital mortality rate compared with that in patients without previous stroke.

Several indicators of stroke severity were associated with 30-day in-hospital mortality, including: stroke due to intracerebral haemorrhage, ICU treatment for stroke, stroke-related neurosurgery and high stroke-related medical expenditure. Preoperative stroke-related co-morbidity, including traumatic brain injury (RR 2·01), dementia (RR 2·10), pneumonia (RR 2·16) and decubitus ulcer (RR 2·35), increased postoperative in-hospital mortality (*Table 3*).

Table 3 Adjusted rate ratios for 30-day mortality associated with stroke-related treatment, characteristics and co-morbidities before surgery

Preop. characteristics for stroke	30-day mortality*	Rate ratio†‡
Patients without stroke§	538 of 45 420 (1·2)	1·00 (reference)
Time period for stroke diagnosis		
Stroke within 13–24 months preop.	424 of 28 348 (1·5)	1·25 (1·10, 1·42)
Stroke within 7–12 months preop.	96 of 6494 (1·5)	1·25 (1·00, 1·55)
Stroke within 1–6 months preop.	436 of 10 578 (4·1)	3·31 (2·91, 3·75)
Low income status¶		
Stroke without low income	913 of 43 878 (2·1)	1·77 (1·59, 1·97)
Stroke with low income	43 of 1542 (2·8)	2·30 (1·68, 3·15)
Type of stroke		
Ischaemic	414 of 24 561 (1·7)	1·42 (1·25, 1·61)
Other unclassified	185 of 11 862 (1·6)	1·36 (1·15, 1·61)
Haemorrhagic	357 of 8997 (4·0)	3·41 (2·97, 3·91)
Preop. ICU stay		
Stroke without ICU stay	541 of 32 243 (1·7)	1·45 (1·29, 1·64)
Stroke with ICU stay	415 of 13 177 (3·2)	2·55 (2·24, 2·90)
Stroke-related neurosurgery		
Stroke without neurosurgery	743 of 39 378 (1·9)	1·61 (1·44, 1·80)
Stroke with neurosurgery	213 of 6042 (3·5)	2·49 (2·12, 2·92)
Stroke-related ME#		
Stroke with very low ME	134 of 9086 (1·5)	1·31 (1·08, 1·59)
Stroke with low ME	146 of 9083 (1·6)	1·39 (1·16, 1·67)
Stroke with moderate ME	145 of 9083 (1·6)	1·36 (1·13, 1·63)
Stroke with high ME	239 of 9084 (2·6)	2·19 (1·88, 2·55)
Stroke with very high ME	292 of 9084 (3·2)	2·35 (2·04, 2·71)
Preop. TBI		
Stroke without TBI	745 of 36 836 (2·0)	1·68 (1·51, 1·88)
Stroke with TBI	211 of 8584 (2·5)	2·01 (1·72, 2·36)
Preop. dementia		
Stroke without dementia	780 of 38 429 (2·0)	1·68 (1·51, 1·88)
Stroke with dementia	176 of 6991 (2·5)	2·10 (1·75, 2·51)
Preop. pneumonia		
Stroke without pneumonia	565 of 32 069 (1·8)	1·54 (1·37, 1·74)
Stroke with pneumonia	391 of 13 351 (2·9)	2·16 (1·89, 2·46)
Preop. decubitus ulcer		
Stroke without decubitus ulcer	849 of 41 932 (2·0)	1·69 (1·52, 1·88)
Stroke with decubitus ulcer	107 of 3488 (3·1)	2·35 (1·91, 2·91)

Values in parentheses are *percentages and †95 per cent c.i. ‡Adjusted for age, sex, teaching hospital, low income, urbanization, co-existing medical conditions, type of surgery and anaesthesia. §Rate ratio of patients without stroke was used as the reference for all categories. ¶Defined as patients qualifying for waived medical co-payment as certified by the Bureau of National Health Insurance. #Preoperative medical expenditure (ME) owing to stroke was categorized into quintiles; the highest quintile was defined as very high ME and the lowest quintile was defined as very low ME. ICU, intensive care unit; TBI, traumatic brain injury.

Discussion

Stroke has been identified as a major risk factor for postoperative mortality and complications. The results of the

present study, which was designed with propensity score matching and adjusted by multivariable regression models, confirm the increased rates of adverse events in patients with a medical history of stroke before surgery. The risk of postoperative death in the propensity score-matched cohort was lower than that in the non-matched cohort. This means that the risk of postoperative mortality would have been overestimated if propensity score matching had not been used, even if multivariable regression analysis had been performed to control for confounders. The matched study design with propensity scoring should therefore be considered for outcome studies[27–29].

The postoperative incidence of pneumonia, septicaemia and acute renal failure increased substantially in patients with previous stroke, as did the incidence of myocardial infarction and pulmonary embolism, although to a lesser extent.

The present study considered stroke-related characteristics and complications as clinical indicators of stroke severity. Dementia, traumatic brain injury, pneumonia and decubitus ulcer were highly correlated with adverse postoperative outcomes in patients with previous stroke. Stroke within 1–6 months before surgery was associated with a greater than threefold increase in the 30-day postoperative in-hospital mortality rate. Patients with a medical history of haemorrhagic stroke, ICU stay, neurosurgery for stroke, and those in the highest quartile of preoperative medical expenditure before surgery had an increased 30-day mortality rate. These findings show a severity-dependent association between stroke and postoperative in-hospital mortality.

Stroke is a manifestation of vascular disease that may lead to more complications and subsequent mortality after surgery. There are, however, several other possible reasons for worse outcomes in patients with a medical history of stroke, including limited physical function, reduced pain sensitivity and mental dysfunction; the latter two factors may delay the diagnosis and treatment of complications[25]. Overdosing or underdosing related to interactions between analgesics, anaesthetics and patients' regular medications may occur[25,30]. Socioeconomic factors such as lack of family support and geographic challenges might hinder some patients from seeking medical services, and this may affect quality of care.

Several limitations of the present study are acknowledged. First, the database lacked detailed information on sociodemographic variables and lifestyle, as well as records of physical and biomedical examinations. Second, this study used ICD codes, which were employed by most physicians for stroke diagnosis. Stroke-related clinical risk scores and information on lesion characteristics were not available for analysis of stroke severity. Third, patients diagnosed with stroke more than 24 months before surgery might have been included in the control group and, conversely, patients with minor symptoms of stroke without emergency treatment or hospitalization might be missing from the cases. Finally, although the accuracy of major diagnostic codes in the National Health Insurance Research Database has been studied[26], the validity of co-morbidity and complications determined by using reimbursement codes needs to be verified.

Notwithstanding the limitations of this study, the results of the present investigation show that patients with a medical history of stroke in the 24-month interval before surgery have a higher incidence of postoperative complications and 30-day mortality.

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Supporting information

Additional supporting information may be found in the online version of this article:

Table S1 Definition of co-existing medical conditions and postoperative complications (Word document)

Table S2 Characteristics of propensity score-matched patients with and without previous stroke who underwent surgery (Word document)

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