Author/s:
Mihailidis, HG;Manners, S;Churilov, L;Quan, GMY

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Authors:

1. Harrison George Mihailidis

- Doctor of Medicine (MD), Master of Clinical Chiropractic (MCChiro)
- University of Melbourne Medical School, Austin Health Clinical School, Australia

2. Simon Manners

- Bachelor of Medicine and Bachelor of Surgery (MBChB), Fellow of the Royal Australasian College of Surgeons (orthopaedics) (FRACS)
- Orthopaedic Spine Fellow Austin Health, Australia

3. Leonid Churilov

- PhD
- Head, Statistics and Decision Analysis Platform, The Florey Institute of Neuroscience and Mental Health, Heidelberg, Australia

4. Gerald M. Y. Quan

- Medical Bachelor, Bachelor of Surgery (MBBS), PhD
- Fellow of the Royal Australasian College of Surgeons (FRACS), Fellow of the Australian Orthopaedic Association (FAOrthA)
- Consultant Orthopaedic Surgeon Austin Health
- Head of Spinal Surgery and Spinal Research, University of Melbourne Department of Surgery, Austin Health

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- Table 1 *List of major and minor complications*

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Corresponding Author:

Harrison Mihailidis

Email: harrison.mihailidis@gmail.com

Phone: (Austin Health): + 61 3 9496 5000 or +61 3 9496 3903

Address: Spinal Biology Laboratory c/o Gerald Quan

Austin Health 145 Studley Rd Heidelberg, Victoria, Australia 3081

Abstract

Introduction: An ageing population and advances in medical management often requires spinal surgeons to increasingly operate on patients older than 80 years of age. The ability to predict complications and mortality rates would allow discrimination of which octogenarians are able to safely undergo spinal surgery. Therefore, the aims of this study were to determine whether co-morbidities and extent of surgery were associated with complications in this age group, in addition which co-morbidity and physical status assessments scales were best associated with development of complications following spinal surgery.

Methods: A retrospective cohort study was performed. Co-morbidities and physical health status were analysed using American Society of Anaesthesiologists (ASA) physical illness rating, Charlson Co-morbidity Index (CCI) and Cumulative Illness Rating Scale for Geriatrics (CIRS-G) score. Complications and extent of operation were sourced from patient records. The association between co-morbidities/extent of operation and complications was analysed using negative binomial regression analysis.

Results: 54 patients were included in our study (22 elective and 32 emergency). 38 patients suffered at least one complication (14 elective and 24 emergency, including 6 deaths). Increasing CIRS-G and CCI scores were associated with increased incidence of total complications in the elective cohort. Increased number of operated spinal levels was also associated with complications.

Discussion: Elective spinal surgery can be safely performed in well selected patients over 80 years of age. However, extent of surgery, CIRS-G and CCI scores were associated with increased complications from spinal surgery in octogenarians.

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Introduction

Over the next 50 years ageing is the most dramatic change projected to occur in the Australian population.[1] Together with modern advances in medical management, this will result in an increasing number of octogenarians presenting with degenerative or emergency (tumour, traumatic or infective) conditions that may require spinal surgery. The decision-making process of spinal surgeons should take into consideration the clinical indications for surgery, the age, general health, physical status, functional independence and survival prognosis of the patient, the predicted recovery and potential risks and benefits of surgery, as well as the natural history of the condition if left untreated. These considerations are very different in the elective versus the emergency setting.

Older patients generally have more co-morbidities and may have different subjective opinions on interventions and outcomes when considering elective spinal surgery, compared with the younger population with similar conditions. Many studies have shown the benefit of elective spinal surgery for symptomatic degenerative conditions such as lumbar spinal stenosis after conservative treatment fails.[2-8] Several studies have shown favourable outcomes following spinal surgery in terms of improvement in pain, function and quality of life in the elderly age group of over 70 to 80 years of age.[3-5] However, others have observed an increased incidence of post-operative complications with increasing age and co-morbidities.[8-10] Certain studies have used physical status scoring systems such as the American Society of Anaesthesiologists (ASA) score and Charlson Co-morbidity Index (CCI) and associated these with complications seen post-operatively.[2, 11-13] It remains unclear as to whether or not the risk: benefit ratio is favourable in octogenarian patients undergoing spinal surgery.

Studies investigating emergency spinal surgery in the elderly have usually focussed on odontoid fractures.[14-18] To the best of the authors' knowledge, no studies exist looking at morbidity and mortality of emergency spinal surgery across other traumatic fractures and other indications (eg. tumour, infection, progressive myelopathy) in this demographic. Further study in this area is required in order to generate evidence on patient outcomes. Consideration should be given as to whether age alone should be an exclusion factor for spinal surgery. The aim of the present study is to examine the association between co-morbidities and extent of surgery with complications following spinal surgery in a cohort of Australian octogenerians treated at a single tertiary-referral centre, therefore helping to determine whether spinal surgery can be safely performed in this age group.

Patients and methods

This study was conducted at Austin Health, Melbourne, Australia, a 1000-bed tertiary referral centre for spinal surgery. The medical records of patients who underwent spinal surgery at Austin Health between January 2010 and March 2015 and were aged 80 or over at the time were retrospectively reviewed. The Austin Health Ethics Committee granted ethics approval for audit activity. Subjects were sourced from the Orthopaedic Spinal Surgery Department database containing information on patient demographics, diagnosis and management.

A total of 61 patients over 80 years of age were identified to have undergone spinal surgery at Austin Health in the aforementioned time frame. Six patients who underwent an additional surgery unrelated to their spinal surgery (eg. cardiac, urological, breast) within two months pre- or post- their spinal surgery were excluded from the dataset, in order to avoid confounding from other surgical interventions. Another single patient was excluded due to insufficient follow-up records. This left a total of 54 patients included in the present study.

Subjects were a priori divided into two subgroups on the basis of whether the surgery performed was classified as elective or emergency, which was determined and recorded on the operation report by the treating surgeon. From the 54 patients included, 22 were elective cases, all of which were performed for degenerative lumbar or cervical canal stenosis. The remaining 32 cases were emergency cases for a variety of indications, including tumour, trauma and infection.

Patient co-morbidities and complications

Hospital records (via Austin Health's Scanned Medical Records) were retrospectively reviewed. Co-morbidities were sourced from anaesthetic, surgical admission and inpatient records. Complications were collected from inpatient, ICU, rehabilitation, outpatient notes and discharge summary records. Length of hospital stay, place of discharge and long term follow-up status were sourced from inpatient and outpatient records. Studies by Carreon et al and Street et al (19,20) provided guidance for identification and classification of complications into major versus minor (Table 1). Complications were defined as an event that occurred as an unintended consequence of surgical management that was detrimental to the patient and not as a consequence of the disease process.

Co-morbidity Scores

Co-morbidities were assessed using three different assessment tools (Table S1). The Charlson Co-morbidity index was calculated using the International Classification of Diseases (ICD-10) coding algorithms[21]. The Cumulative Illness Rating Scale for Geriatrics (CIRS-G) score was generated using guidelines described by Miller and Towers.[22] The American Society of Anaesthesiologists (ASA) physical status classification system[23] rating was obtained from anaesthetic records and was determined by the anaesthetist at the time of surgery.

Statistical Methods

Statistical software STATA IC V13 (StataCorp, College Station, TX, USA) was used for statistical analysis. Descriptive data were presented as mean and standard deviation (SD), or median and Interquartile range (IQR) as appropriate. Due to the count nature of the outcome variable (number of complications), two alternative models for count outcomes were originally considered. On the assessment of model fit, negative binomial regression model was strongly preferred to the Poisson model, therefore negative binomial regression models with the per patient complication count as an output variable and appropriate clinical scores and surgery type (elective/emergency) as input variables were used for analysis.

Results

The median age of all patients was 83 (IQR= 85-80, mean 83.6, SD=2.8) with elective cases having a median age of 82.5 (IQR=81-84, mean 82.2, SD=2.4) and emergency cases a median age of 83.5 (IQR=82-86.5, mean 84.1, SD=2.9). There were a total of 31 males (57.4%) and 23 females (42.6%), with 7 (31.8%) males and 15 females (68.2%) comprising the elective subgroup and 24 (75%) males and 8 (25%) females in the emergency subgroup. The median follow-up time period was 8.5 months (IQR 3.75-12.5, mean 10.6, SD 10.3).

The median operating time on all patients was 180 minutes (range 60-270, IQR=139-209, mean 174, SD=47) with a median of 3 levels operated on (range 1-11, IQR=2-5, mean 3.8, SD=1.9). The median time spent on the surgical ward post-operatively was 9 days (IQR=6-14.8, mean 12.9 days, SD 11.4). The elective subgroup had a median of 7 days (mean 10.2 days) and the emergency subgroup a median of 10.5 days (mean 14.8 days) post-operative inpatient stay.

16 patients (29.6%) did not develop any post-operative complications. 38 (70.4%) patients had at least one complication. The incidence of at least one major complication was 38.9% (21

patients) and at least one minor complication was 68.5% (37 patients). When considering the elective subgroup of patients, the incidence of at least one complication was 63.6% (14 patients); 36.4% (8 patients) had at least one major complication and 59.1% (13 patients) had at least one minor complication. In the emergency subgroup, the incidence of at least one complication was 75% (24 patients); 40.6% (13 patients) had at least one major complication and 75% (24 patients) had at least one minor complication.

There were no post-operative deaths in all the patients who underwent elective spinal surgery throughout the follow-up period. The emergency subgroup had 3 inpatient deaths (9.4% of emergency cases) within 30 days and a further 3 deaths beyond 30 days post-operatively. There were no other deaths noted on follow-up, with a minimum follow-up period of 6 weeks. The risk difference between the elective and emergency subgroups in terms of mortality was 0.18 (95% CI 0.05-0.32, p=0.07).

Median CIRS- G score was 14 (IQR 12-16, mean= 13.8, SD=3.9) with CIRS-G being statistically significantly higher in the emergency group (p <0.001). CIRS-G score in the elective group had a median of 11.5 (mean 11.6), emergency group had a median of 15 (mean 15.3). Association was found between increasing CIRS-G score and total number of complications. For the entire cohort an increase of 1 point on CIRS-G was associated with an increase of total number of complications by a factor of 1.1 (95% CI= 1.04-1.16, p=0.001). This result remained virtually unchanged when adjusted for the surgical indication (emergency and elective), with a factor of 1.11 (95% CI= 1.04-1.17, p=0.001). On the subgroup analysis a 1-point increase in CIRS-G score was associated in an increase in total number of complications by a factor of 1.16 (95 %

CI=1.07-1.25) in the elective subgroup ($p<0.001$) and an increase by a factor of 1.04 (95% CI= 0.95-1.14) in the emergency subgroup, although this was not statistically significant ($p=0.36$). Formal surgery subgroup analysis (emergency versus elective) by CIRS-G interaction or any of the other scores was unable to be performed due to low power, therefore no conclusions regarding comparison between these subgroups can be drawn.

In terms of major complications, for the entire cohort an increase in CIRS-S by 1 point was associated with an increase by a factor of 1.15 (95% CI= 1.04-1.28, p= 0. 008). When considering elective and emergency surgeries as subgroups, the elective subgroup showed an increase by a factor of 1.25 (95% CI= 1.09-1.43) for a 1-point increase in score (p=0. 002). Again, the results for the emergency subgroup were not statistically significant (increase by factor 1.04, $p>0.05$). Considering minor complications, the elective subgroup showed an increase by a factor of 1.1 for minor complications with a 1 point increase in CIRS-G score (95% CI= 1.01-1.23, $p=0.02$). Findings in the emergency cohort of patients were not statistically significant (increase by factor of 1.02, $p>0.05$). Statistical models were attempted to associate minor complications to CIRS-G for the total cohort, however numerical convergence was not achieved.

The mean CCI score across the entire patient cohort was 2.4, with an elective subgroup mean of 1.6 and emergency subgroup mean of 3. An emergency patient was more likely to have a higher CCI score compared with patients undergoing elective spinal surgery ($p=0.01$). In the elective subgroup of patients, an increase per point of the CCI score was associated with an increase in total complications by a factor of 1.23 (95% CI= 1.02- 1.47, $p=0.02$) and major complications by a factor of 1.35 (95% CI= 1.07-1.69, p=. 01). No other significant results were obtained when associating CCI with the total cohort complications, emergency cohort complications and minor complications in the elective cohort.

Associations between ASA scores and complications were not statistically different between the elective and emergency groups. No significant results were produced comparing total, major and minor complications to our total population, adjusting for subgroup and then analysing each subgroup individually. Description of ASA, CCI and CIRS-G scores for the patient cohort are shown in Table S2.

The number of operated spinal levels was associated with an increased total complication rate. A one-level increase was associated with an increase in complications by a factor of 1.11 (95% CI= 1.002-1.234, p= 0.04). When adjusted for sex all of the regression results remained materially the same.

Discussion

Spinal surgery may be safely performed in selected octogenarians, with our findings showing that up to 30% of patients recovered without a single complication following both elective and emergency spinal surgery. This is in keeping with other studies that have shown elective surgery to be safe in physically well octogenarians and that advanced age itself is not a contraindication to surgery. [3,4,6,8] The overall complication rate in our study of 70.3% is comparable to two previous prospective studies examining complication rates of spinal surgery. Street et al[20] showed a complication rate of 87% for at least one complication in spinal surgical patients across all ages and for all indications. Another study by Campbell et al [24] showed a complication rate of 59.4% for thoracic and lumbar surgery. Consideration of overall physical health and co-morbidities in the elderly age group is important during the informed consent process so that octogenarian patients who have the potential to recover well and benefit from spinal surgery may undergo treatment. Ideally, the development of a universal scoring system that can be readily clinically applied and that has been validated as being predictive of estimating risk of post-operative complications would be beneficial in the decision-making process.

We observed an increased CIRS-G score being associated with increased risk of developing complications following spinal surgery in octogenarians. The CIRS-G score is not only increased by the number of co-morbidities, it also increases with the severity of the co-morbidity. It follows that from the associations found between increasing CIRS-G score and complications, the presence and severity of co-morbidities in this age group may play a role in the development of complications seen following elective spinal surgery. The CCI score also had a significant association with major and total complications in elective patients. This is consistent with other studies that have suggested that CCI score can be predictive of complications following spinal surgery.[2,16] The CCI score considers conditions that have been weighted on the basis of their association with one year mortality but is not as comprehensive a scoring system compared to the CIRS-G score as it does not take into account the severity co-morbidity. However, it may be applied more readily in a clinical setting as it is not as time intensive to calculate as the CIRS-G score. Although previous studies have shown that complications following elective spinal surgery in patients in the over 80-age group are associated with increased ASA score, [2,16-18] which is also easily clinically applied, our study did not find significant results in terms of association between increasing ASA score and complications.

We did not observe statistically significant results in the emergency subgroup of patients. We hypothesise that this may be due to the heterogeneous range of conditions for surgery in the emergency group playing an understated role in the physical status of the patient and thus the likelihood of operative complications. Indications and outcomes following emergency spinal surgery should be thought of differently to that of elective spinal surgery. Specifically, the risk of mortality and morbidity of not performing surgery must be weighed against the risks of surgery. The emergency cohort had a variety of conditions that carried a high risk of mortality, thus surgery was performed with the aim of prevent mortality or the severe morbidity that would likely ensue if patients were left non-operated. Indications for emergency spinal surgery included pathological fractures and metastatic epidural spinal cord compression, traumatic spinal fractures, spondylodiscitis and cauda equina syndrome. If we are to consider other non-elective orthopaedic surgical conditions that commonly occur in the elderly, such as hip fractures, we find that the incidence of mortality and morbidity is higher with delayed or non-operative management compared with surgery. [25-28] It follows that this would likely occur in the emergency subgroup of octogenarian patients in our study without operative management. Further research into the specific clinical indication for emergency spinal surgery and the impact this has on physical status and overall survival prognosis, considered together with co-morbidities in predicting risk of morbidity and mortality with or without spinal surgery is required.

Another factor that must be taken into account is the magnitude of the surgery performed, especially the number of spinal levels operated on. Our study showed that a one-level increase in surgery increased total complication rate by 11%. The 30-day post-operative mortality rate in our study when including elective and emergency groups was 5.6%. This is comparable to a larger prospective study by Hamel et al[29] who observed a 30-day mortality rate of 8% for non-cardiac surgical interventions in patients aged over 80. Limitations of this study include the retrospective nature, the lack of a comparison group of younger patients and an insufficient number of patients in the emergency subgroup to yield statistically significant results. Furthermore, patients in the elective group may represent only well selected, physically robust octogenarians that surgeons are happy to operate on and may not be representative of the average octogenarian with a condition that can be managed with elective spinal surgery.

In conclusion, although spinal surgery may be safely performed in selected octogenarians, the presence and severity of patient co-morbidities as well as magnitude of surgery should be considered when deciding to operate on the spine in the elderly age group. We found that increased CIRS-G and CCI scores were associated with the development of increased post-operative complications following elective spinal surgery and thus may be beneficial in applying pre-operatively during the consent process prior to embarking on spinal surgery. When considering emergency spinal surgery in octogenarians, our study might serve as a preliminary study to a larger multi-centre prospective study looking at specific diagnoses for emergency spinal surgery separately and examining clinical and functional outcomes as well as morbidity and mortality, in order to further guide the surgical decision-making process.

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List of Supporting Information

Table S1 Summary descriptions of co-morbidity scores

Table S2 *Breakdown of patient ASA, CCI and CIRS-G scores*

Tables

Table 1

List of major and minor complications

Major Complications	*Minor Complications*
Pneumonia	Blood transfusion
Respiratory distress	Urinary Complication (Urinary tract infection, Retention, Haematuria, Incontinence)
Acute Kidney Injury	
	Gastrointestinal (Constipation/Ileus, Vomiting, Haematemesis)
Myocardial Infarction	
Other Cardiovascular (Acute pulmonary oedema, new onset atrial fibrillation, Exacerbation of congestive cardiac failure)	Dural Tear Confusion TIA
Pulmonary Embolism	DVT
Sepsis	Medical Emergency Team (MET) Call for any other cause

Neurological deficit ICU admission for any other cause	Wound seroma