Complications in spinal deformity surgery in the United Kingdom: 5-year results of the annual British Scoliosis Society National Audit of Morbidity and Mortality

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Received: 1 December 2013 / Revised: 11 January 2014 / Accepted: 11 January 2014 / Published online: 24 January 2014
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Abstract

Purpose To provide a 5-year national overview of corrective spinal deformity surgery in the United Kingdom.

Methods Since 2008, the British Scoliosis Society has collected predefined data on spinal deformity surgeries carried out by its members. Participating units collect and submit annual anonymised data pertaining to the number of deformity surgeries performed, age groups, aetiology (idiopathic versus non-idiopathic), mortality, deep infections and neurological deficit (complete, incomplete without resolution and incomplete with resolution). Overall aetiology proportions and complication rates were calculated, as well as funnel plots with control limits of individual complication rates by cases performed.

Results Between 2008 and 2012, 9,295 corrective spinal deformity procedures were performed. 4,445 (48 %) were recorded as idiopathic and 2,917 (31 %) as non-idiopathic. There were a total of 339 complications (3.6 %). Deep infections occurred in 222 (2.82 %), incomplete neurological deficit with resolution in 59 (0.65 %), incomplete

neurological deficit without resolution in 29 (0.32 %), complete neurological deficit in 12 (0.13 %) and mortality in 17 (0.19 %).

Conclusion The complication rates reported in this study compare well with previously published studies. These reported results will hopefully serve to provide a benchmark for units in the UK providing corrective spinal deformity surgery to allow individual units to compare their complication rates against national averages and to provide national complication figures to aid in the consenting process of patients. Use of a spinal deformity registry, such as the British Spine Registry, is required to ensure ongoing service development and optimal health-care provision.

Keywords Spinal deformity · Scoliosis · Kyphosis · Surgery · Complication rate

Introduction

Spinal deformity refers to a heterogeneous group of conditions defined by an abnormal deviation from normal spinal shape. The common spinal deformities include scoliosis and kyphosis. Scoliosis has traditionally been described as a spinal deformity of $>10^\circ$ in the coronal plane as described by Kane [1]. The description of a three-dimensional structural deformity of the spine and trunk [2, 3] is more anatomically accurate and currently accepted. Thoracic kyphosis refers to the forward curvature of the spine (in the sagittal plane). Normal physiological thoracic kyphosis is age and sex dependent, increasing with age and more so in females [4]. Abnormal thoracic kyphosis is generally accepted to be outwith the normal range of $20\text{--}50^\circ$ in children [5].

Work originally presented at The BSS Annual Meeting, Stoke-on-Trent, 12 September 2013.

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Table 1 Summary of pooled major complication rates by aetiology (adapted from Weiss et al. [6])

Aetiology	Pooled major complication rate (range) (%)
Congenital	3 (0–9)
Neuromuscular	17.4 (0–39)
Idiopathic	8.6 (0–37)
Adult	30 (10–62)

Major complications were considered to be deep wound infection, pseudoarthrosis, transition syndrome, neurologic deficit, and death

Reported complications following corrective spinal deformity surgery are varied, reflecting the heterogeneity of this group in terms of age (paediatric, adolescent, adult), aetiology (congenital, neuromuscular, idiopathic, degenerative), surgical approach (anterior, posterior, combined) and surgical procedure (type of instrumentation, use of osteotomies). In a systematic review of published scoliosis complication rates, Weiss et al. [6] surmised that complication rates in scoliosis surgery are high but variable. Table 1 summarises their pooled data on major complication rates by aetiology.

The complication rates associated with corrective spinal deformity surgery across the United Kingdom are largely unknown. O'Dowd and Courtier [7] reported on the first 3 years of use of the British Spinal Registry (a web-based registry for voluntary submission of spinal surgery, outcomes and complications) between 2004 and 2007. There were 448 deformity cases in this report with the following complication rates: no intraoperative deaths, no complete spinal cord injuries, 4 partial spinal cord injuries (0.9 %), 6 deep infections (1.3 %) and 14 implant revisions (3.1 %).

The British Scoliosis Society (BSS) represents surgeons, healthcare workers and researchers interested in the nature and treatment of scoliosis and complex spine disorders. From 2008, the Society has annually collected predefined aetiological and outcome data pertaining to spinal deformity surgeries carried out by its members. The aim of this audit is to provide a national overview of corrective spinal deformity surgery in the United Kingdom, including case volume and major complication rates. The results of the audit have been presented, on an annual basis, at the Annual General Meeting of the BSS. This paper presents the results of the first 5 years of the audit.

Methods

Individual units were approached on an annual basis between 2008 and 2012 by the BSS and asked to submit data pertaining to deformity surgery carried out in their unit. Data submission was voluntary and outcome

measures were predefined by the Society. Each unit collected and submitted annual anonymised data via an electronically submitted survey. Data submitted included the number of deformity surgeries performed, age groups, aetiology (idiopathic versus non-idiopathic), mortality, deep infections and neurological deficit (complete, incomplete without resolution and incomplete with resolution).

Data on mortality, deep infections and neurological deficit are presented as totals and rates (per 1,000) over the study period. Additionally, these complications were individually analysed further in comparison to the number of cases performed per unit by way of funnel plots with control limits as described by Dover & Schopflocher [8] and Spiegelhalter [9]. Individual complication rates (per 1,000) were plotted against the number of cases performed along with the total complication rate, 95 % (± 2 SE) and 99.8 % (± 3 SE) control limits. Funnel plots are a useful way of detecting outlying data points, as recommended in guidelines set out by the National Clinical Audit Advisory Group (for the Department of Health/Healthcare Quality Improvement Partnership) on the analysis and monitoring of healthcare outcome data [10].

Results

A total of 9,295 corrective spinal deformity procedures were performed between 2008 and 2012. Figure 1 summarises the number of cases performed and the number of participating units by year. Patients were grouped at the point of data collection into the following age groups: less than 10 years, between 11 and 16 years, between 17 and 29 years and over 30 years. Figure 2 summarises the total number of cases by age group. Out of the 9,295 cases submitted, 4,445 (48 %) were recorded as idiopathic and

Fig. 1 Graph of number of cases performed and contributing units by year

Fig. 2 Graph of cases performed by age group

Table 2 Summary of complications (*n*—number of complications; *N*—subgroup total accounting for incomplete data submission)

Complication	<i>n</i>	<i>N</i>	Rate (%)	Rate per 1,000
Deep infection	222	7,848	2.82	28
Neurological deficit				
Incomplete with resolution	59	9,136	0.65	6.5
Incomplete without resolution	29	9,136	0.32	3.2
Complete	12	9,136	0.13	1.3
Mortality	17	9,136	0.19	1.9
Total	339	9,295	3.64	36.4

2,917 (31 %) as non-idiopathic. The remaining 1,933 (21 %) did not have a diagnosis submitted.

Table 2 summarises the overall complications reported and Fig. 3 demonstrates the individual complications by year. There were a total of 339 complications, giving an overall complication rate of 36 per 1,000 cases performed (3.6 %). Deep infections occurred in 222 (2.82 %), complete neurological deficit in 12 (0.13 %) and mortality in 17 (0.19 %). Funnel plots of individual unit's rates (per 1,000) for deep infection (Fig. 4), complete neurological deficit (Fig. 5) and mortality (Fig. 6) were plotted against case volume along with 95 and 99.8 % control limits. It would be expected that the majority of units lies within the 95 % control limits and certainly most should lie within the 99.8 % control limits. Those outwith these control limits are considered outliers. However, caution must be taken when interpreting these funnel plots as no risk adjustments have been made on the individual centre results based on the age group proportions or aetiology proportions. For example, units operating on a greater proportion of neuromuscular or congenital scoliosis patients will have higher

Fig. 3 Graph of complication rates (per 1,000) by year

Fig. 4 Funnel plot of Deep infection rate (per 1,000) by number of cases performed

complication rates as a reflection of this and therefore be an outlier on these funnel plots.

As non-idiopathic cases have historically been associated with greater complication rates, outliers (those units lying outside the 95 % confidence interval on the funnel plots) and inliers (within the 95 % confidence interval) were summarised in 2×2 contingency tables according to the individual proportion of non-idiopathic cases (Table 3). The proportion of non-idiopathic cases were grouped into 0–0.3 and greater than 0.31. This stratification was chosen based on the total proportion of non-idiopathic cases in this series (0.31). Fisher's exact test (2-tailed) was applied to

Fig. 5 Funnel plot of complete neurological deficit rate (per 1,000) by number of cases performed

Fig. 6 Funnel plot of mortality rate (per 1,000) by number of cases performed

Table 3 Contingency table of outliers by proportion of non-idiopathic cases

Proportion non-idiopathic	Deep infection		Complete neuro deficit		Mortality	
	Outlier	Inlier	Outlier	Inlier	Outlier	Inlier
0–0.3	7	26	1	33	1	33
>0.31	3	34	4	33	3	34
Fisher's exact test <i>p</i> value	0.173		0.359		0.616	

test for a difference in proportions. Whilst there was a greater proportion of outliers in the >0.31 non-idiopathic proportion group for complete neurological deficit and mortality, this did not reach statistical significance.

Discussion

The complication rates reported in this current study are consistent with previously published studies on complication rates in corrective spinal deformity surgery (Table 4), although direct comparisons are difficult to make due to wide variations in age groups and aetiologies. These reported results will hopefully serve to provide a benchmark for units in the UK providing corrective spinal deformity surgery to allow individual units to compare their complication rates against national averages and to provide national complication figures to aid in the consenting process of patients.

This is the second multi-centre report on complication rates in corrective spinal deformity surgery in the UK. O'Dowd and Courtier [7] reported the first multi-centre audit of spinal surgery in the UK. This included degenerative lumbar surgery and deformity surgery. They gathered data from a web-based registry supported by the BSS. Patient and outcome data were collected from 55 centres across the UK over 3 years from 2004. A total of 1,410 episodes were included, of which 448 were deformity cases. In terms of aetiology, 223 (50 %) were idiopathic, 49 (10 %) neuromuscular and 20 (5 %) congenital. In their report, complication rates were as follows—14 implant revisions (3.1 %), 6 deep infections (1.3 %), 4 partial cord injuries (0.9 %), no complete cord injuries and no deaths. Whilst the reported complications from this large multi-centre, UK registry-based audit is comparable to other published data (as summarised in Table 4), the authors noted that uptake and usage of the web-based registry were low, with a decline in numbers submitted between each year in the 3-year period. The strength of this current study lies in the large number of cases collected from multiple spinal units across the UK, which should minimise the effects of specific factors associated with certain spinal units or geographical patient subpopulations. Furthermore, as demonstrated in Fig. 1, the number of contributing units and cases submitted increases yearly throughout the study period indicating improving uptake with this audit process.

Weaknesses of this study lie in the dependence on accurate data collection and submission by the individual units, which has been done voluntarily. Thus, these reported complication rates could be underestimated. Weiss et al. [6] draw attention in their systematic review to the need for mandatory, standardised reporting of corrective spinal deformity surgery complications and especially of long-term outcomes. Interestingly, membership with The Scoliosis Research Society (USA) mandates members to submit morbidity and mortality data for ongoing audit. This is currently not a stipulation of membership with the BSS, but may become necessary in the future to ensure accurate, representative, nationwide data collection. The

Table 4 Summary of published complication and mortality rates

	Year	<i>n</i>	Type	Deep infection (%)	Complete neurological deficit (%)	Incomplete neurological deficit (%)	Mortality (%)	Total complications (%)
Coe et al. [11]	2006	6,334	Adolescent idiopathic scoliosis	–	–	–	0.03	5.7
Daubs et al. [13]	2007	46	Adult	4.4	8.7 (reported as all neurological deficit)	–	4.34	20
Dowd et al. [7]	2008	448	Mixed	1.3	0	0.9	0	
Yadla et al. [14]	2010	2,175	Systematic review. Adult	–	–	–	–	41.2
Drazin et al. [15]	2011	815	Systematic review. Adult	5.2	4.7 (reported as all neurological deficit)		0.76	38.2
Reames et al. [12]	2011	19,360	Paediatric	1.7	0.09	0.5	0.13	10.2
Current study	2013	9,295	Mixed	2.8	0.13	0.96	0.19	3.64

importance of this is even more crucial with performance-related assessment of surgical service provision becoming more central to NHS practice and clinical governance.

We would advise caution in using these presented funnel plots of complications to gauge an individual unit's performance, as no risk adjustments were made for aetiology or for age. Unfortunately, data were not submitted for this audit in a way that would allow risk adjustment/stratification according to age groups and aetiologies. Data were submitted as group totals per year, instead of individual cases with individual demographics and complications. It was felt that a more complicated data submission process might lead to poor uptake given the voluntary nature of this audit process. An appropriate standard reference population could not be determined from the literature as this is the first large, mixed age/aetiology cohort study from UK-based spinal units. It was not felt appropriate to risk adjust these reported results based on the large Scoliosis Research Society Morbidity & Mortality database results published by Coe et al. [11] in 2006 or later by Reames et al. [12] in 2011 given the differing underlying study population characteristics.

Further development of a nationwide corrective spinal deformity surgery registry, which should include type of deformity, severity indicators, aetiology, procedures performed, complication rates and patient reported outcome measures (PROMS), is required to ensure ongoing service development and optimal healthcare provision. The BSS is a partner in the new British Spine Registry (www.spinerregistry.co.uk), which is a web-based database, allowing prospective collection of these details, and as such encourages all members to participate.

Acknowledgments No financial support was received for this study.

Conflict of interest The authors declare no conflict of interest.

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