

Postoperative Pulmonary Complications in Complex Paediatric and Adult Spine Deformity: A Retrospective Review of Consecutive Patients Treated at SRS GOP Site in Ghana

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Research article

Keywords: Complex spine deformity; Pulmonary complications; late presentation; Forced Vital Capacity; Halo Gravity Traction; FVC; pediatric deformity; scoliosis; Pulmonary function tests; PFT; complications; Preoperative management.

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Abstract

Background Pulmonary complications are important cause of morbidity and mortality in patients following spinal surgeries. There is paucity of literature on pulmonary complications following complex spine deformity surgery in underserved regions. This study sought to assess the incidence and risk factors of pulmonary complication following complex spine deformity surgery Methods Data of 276 complex spine deformity patients aged 3-25yrs who were consecutively treated at a single site were retrospectively reviewed. Data was analyzed using Stata 14 software. Patients were labelled into two groups: Grp 1: patients with pulmonary complications(N=17) vs Grp 2: patients with no pulmonary complications (N=259). Comparative analysis for risk factors included independent t-test and chi square test for independence. Multivariate logistic regression analysis was also performed. Results The incidence proportion of pulmonary complication was 17/276 (6.1%) (Grp 1) while 259 pts had no pulmonary events (Grp 2). There were 8M/9F for Grp 1 vs 100M/159F Grp 2, $p=0.48$. BMI was similar in both groups (17.2 vs 18.4 kg m^{-2} , $p=0.15$). Average pre-op sagittal Cobb (90.6 vs 88.7deg, $p=0.87$), coronal Cobb (95 vs 88.5deg, $p=0.43$), Pre-Op FVC (45.3 vs 62.0%, $p=0.02$), Pre-Op FEV1 (41.9% vs 63.1, $p<0.001$), Grp 1 vs Grp 2, respectively. EBL, OR time and Surgery Levels were similar in both Grps. Thoracoplasty was performed in 41.18% vs 21.57%, $p=0.06$, SPO 47.06% vs 42.31%, $p=0.04$ and VCR 5.88% vs 20.31%, $p=0.145$, Grp 1 vs Grp 2, respectively. Multivariate logistic regression showed that every unit increase in pre-Op FVC (%) decreases the odds of pulmonary complication by 5% (OR=0.95, 95% CI 0.90 to 0.99, $p=0.045$). Conclusion The observed 6.1% incidence of pulmonary complications is comparable to reported series. Only pre-Op FVC was an independent predictor of pulmonary complications. The observed case fatality rate (17%) following pulmonary complications highlights the need for thorough preoperative evaluation to identify high risk patients. Key words: Complex spine deformity; Pulmonary complications; late presentation; Forced Vital Capacity; Halo Gravity Traction; FVC; pediatric deformity; scoliosis; Pulmonary function tests; PFT; complications; Preoperative management.

Background

The surgical management of complex spine deformity is technically challenging and associated with significant perioperative complications [1-8]. Post-operative(post-op) pulmonary complications remain one of the leading causes of mortality even in adult spine surgery [5-6]. The cumulative incidence of pulmonary complications after spine surgery has ranged from 0.9 to 9.8% [7-12]. The differences in incidence are attributable to the variations in the definition of pulmonary events in the various studies [7-12].

The concern for pulmonary complications is even greater in developing regions with limited expertise and resources. Patients in these regions typically report to health facilities when spine deformities have significantly progressed [13]. These severe deformities are associated with poor pulmonary function [14-18]. Impaired pulmonary function increases the risk of post-op pulmonary complications after spine surgery [18]. Besides, spine surgery for these patients is characterized by significant blood loss, long operative time, and the use of three column osteotomies which further increases the risk for neurologic

and non-neurologic complications [1]. The presence of comorbidities coupled with major surgical procedures further increases the risk of pulmonary complications [9]

The mechanism of pulmonary complication following spinal surgery may be related to direct trauma, embolization of marrow material into the lung including fat, ventilation-association lung injury and transfusion-associated lung injury [19-23]. Post-op pulmonary complications increase the risk of mortality after spine surgery [5,6,7]. Aside mortality, post-op pulmonary complications can affect the length of stay and cost of hospitalization [7]. Identification of risk factors for pulmonary complications would help avert these outcomes. However, there is paucity of literature on pulmonary complications following complex pediatric spine deformity surgery in underserved regions such as West Africa. This study sought to investigate the incidence and risk factors for pulmonary complications following complex pediatric and adult spine deformity surgeries in specialist Orthopaedic Hospital in Ghana, West Africa.

Methods

Data of 276 consecutive complex spine deformity patients aged 3-25yrs who were treated at a single site in Ghana from January, 2015 to December, 2017 were retrospectively reviewed using information from the FOCOS Spine Registry, electronic records and filed folders. Institutional Review Board (IRB) approval was obtained from the Noguchi Memorial Institute for Medical Research (NMIMR) prior to initiation of the study (Certified Protocol Number: 057/16-17). Research data was initially extracted in excel format and exported into Stata 14 Software for analysis. The primary outcome reviewed was post-op pulmonary complications which was defined as any pulmonary event following spine deformity surgery including respiratory distress, prolonged intubation of more than 48hrs, re-intubation, pneumonia, Acute respiratory distress syndrome (ARDS), significant pneumothorax and tracheostomy. Record review for the primary outcome was restricted to pulmonary complication events that occurred within the first six (6) weeks after surgery. All deformity etiology types were included in the analysis. Patients were divided into two groups during data analysis: Group 1: patients who developed pulmonary complications and Group 2: patients who did not develop pulmonary complications (Differences between the groups were not known prior to data collection). Comparative analysis was performed between the two groups to identify the risk factors. Multivariate logistic regression analysis was performed to evaluate the strength of the association.

Results

A total of 276 paediatric and adult deformity patients were reviewed. 94 patients (34.06%) were aged 3-10yrs, 141 patients (51.09%) were aged 11-17yrs, and 41 patients (14.86%) were aged 18-25yrs. Surgical procedures included posterior only in 262 patients, combined anterior and posterior in 7 patients and 7 two-staged posterior only performed at average 1 week apart. Etiology of the deformities was Idiopathic in 145 patients (52.54%), Congenital in 59 patients (21.38%), Post-tubercular (Post TB) in 44 patients (15.94%), Neuromuscular in 14 patients (5.07%), and Neurofibromatosis in 14 patients (5.07%). For curve type, 154 patients (55.8%) had Scoliosis, 60 patients (21.74%) had Kyphosis and 62 (22.46%) had

kyphoscoliosis. A total of 17 patients had post-op pulmonary complication (Group 1) representing a cumulative incidence of 6.16%. 259 patients had no pulmonary complications (Group 2). Gender ratio (M/F) was similar in both groups: 0.89 versus(vrs) 0.63. Mean age were 13.2years (± 5.0) and 12.5years (± 4.48) in Group 1 and Group 2, respectively ($p=0.55$).

The mean pre-operative (pre-op) Body Mass Index (BMI) was comparable in Group 1 ($M=17.2 \text{ kg/m}^2 \pm 2.31$) and Group 2 ($M= 18.4 \text{ kg/m}^2 \pm 3.49$, $p=0.15$). Pre-op sagittal Cobb angles were similar in both groups ($M=90.6^\circ \pm 39$ vrs $M=88.7^\circ \pm 48$, $p=0.87$), respectively. The range of pre-op sagittal Cobb angles were $41\text{-}203^\circ$ (Group1) vrs $11\text{-}263^\circ$ Group 2. Average pre-op coronal Cobb in Group 1 was 95° (± 24.68) compared to 88.5° (± 32.28) in Group 2 ($p=0.43$). The range of pre-op coronal Cobb angles were $56\text{-}144^\circ$ (Group1) vrs $18\text{-}231^\circ$ (Group 2).

In terms of pulmonary function, pre-op Forced vital capacity (FVC) (%) was significantly lower in Group 1 ($M=45.3 \pm 15.59$) compared to Group 2 ($M=62.0 \pm 24.69$, $p=0.02$). Likewise, pre-op forced expiratory volume in one second (FEV1) (%) was lower in Group 1 ($M=41.9 \pm 15.45$) compared to group 2 ($M=63.1 \pm 21.13$, $p<0.001$). Post traction FVC and FEV1 were similar in both groups. (**Table 1**).

The average duration of surgery (min) in Group 1 ($M=183.7 \pm 63.09$) was comparable to that of Group 2 ($M=189.6 \pm 80.72$, $p=0.77$). Average number of levels fused in Group 1 ($M=13.87 \pm 2.63$) was similar to that of Group 2 ($M=12.46 \pm 2.99$, $p=0.07$). The average estimated blood loss (EBL) in Group 1 ($M=1021 \text{ mls} \pm 683$) was comparable to Group 2 ($M=1011 \text{ mls} \pm 911$, $p=0.93$). In terms of osteotomies, Smith-Petersen osteotomy (SPO) was performed in 47% of patients in Group 1 compared to 42% of patients in Group 2 ($p=0.04$), and vertebral column resection (VCR) was performed in 5.88% of patients in Group 1 compared to 20.31% in Group 2 ($p=0.145$). Thoracoplasty was performed in 41.18% and 21.57% in Group 1 and Group 2, respectively ($p=0.06$). (**Table 1**)

Table 1: Summary of demographic, clinical and surgical logs by post-op pulmonary complication status

Category	Post-operative Pulmonary Complication Status		p-value
	Yes (Group 1) N = 17	No (Group 2) N=(259)	
Age			
3-10yrs	4 (23.53%)	90(34.75%)	
11-17yrs	10 (58.82%)	131(50.58%)	
18-25yrs	3 (17.75%)	38(14.67%)	0.69
Gender (Male/Female)	8/9 (0.89)	100/159(0.63)	0.48
BMI(kg/m ²)	17.2±2.31	18.4± 3.49	0.15
Etiologies			
Idiopathic	7 (41.18%)	138 (53.28%)	
Congenital	5 (29.41%)	54 (20.85%)	
Post Tuberculous	1 (5.88%)	43 (16.60%)	
Neuromuscular	2 (11.76%)	12(4.63)	
Neurofibromatosis	2 (11.76%)	12(4.63%)	0.254
Pre-op sagittal cobb	90.6 ±39	88.7 ± 48	0.87
Pre-op coronal cobb	95±24.68	88.5±32.28	0.43
Post traction sagittal cobb	78.0±22.6	84.3±38.6	0.60
Post traction coronal cobb	73.1±19.8	79.7± 19.7	0.37
Pre-Op FVC (%)	45.3 ±15.59	62.0 ± 24.69	0.02***
Pre-Op FEV1 (%)	41.9±15.45	63.1± 21.13	<0.001***
Post-Traction FVC	46 ± 14.93	55.45 ± 18.65	0.10
Post-Traction FEV1	45.73 ± 15.68	54.84 ± 16.27	0.08
EBL(ml)	1021±683	1011± 911	0.93
Duration of Surgery (min)	183.7±63.09	189.6±80.72	0.77
Surgery Levels	13.87±2.63	12.46±2.99	0.07
Thoracoplasty	7/17(41.18%)	55/255 (21.57%)	0.06
SPO	8/17(47.06%)	62/255 (42.31%)	0.04***
VCR	1/17(5.88%)	52/256(20.31%)	0.145

*** means significant at 0.05 alpha level.

Continuous variables are reported as mean± SD ,

Categorical variables are reported as frequencies (column %)

BMI: Body Mass Index

FVC: Forced vital capacity

FEV1: Forced Expiratory Volume in one second (FEV1)

EBL: Estimated Blood Loss

SPO: Smith-Peterson Osteotomy

VCR: Vertebral Column Resection

Predictors of Pulmonary Complications in Multivariate Analysis

Only Pre-operative FVC was found to be a significant independent predictor of pulmonary complication in multivariate analysis. Multivariate logistic regression revealed that every 1% increase in pre-operative FVC

decreases the odds of pulmonary complication by 5% (OR=0.95, 95% CI 0.90 to 0.99, p=0.045), after controlling for age, curve type, curve etiology, BMI, gender, pre-op sagittal and coronal cobb angles, duration of surgery, EBL, thoracoplasty, SPO, PSO and VCR. (Table 2)

Table 2: Multivariate Logistic Regression Estimates of the Risk Factors for Pulmonary Complications

Table 2				
Risk factors	Odds Ratio	95% Confidence Interval		p-value
		Lower	Upper	
AGE	1.11	0.86	1.43	0.427
BMI	0.85	0.65	1.11	0.227
Gender (Female)	0.53	0.11	2.43	0.413
Curve Type				
Scoliosis	Ref.	-	-	-
Kyphosis	1			
Kyphoscoliosis	1.20	0.13	11.00	0.870
Etiology				
Idiopathic	Ref.	-	-	-
Congenital	2.94	0.33	25.80	0.331
Post Tuberculous	1			
Neuromuscular	2.81	0.14	54.56	0.494
Neurofibromatosis	2.12	0.13	33.12	0.591
Pre Op Coronal Cobb	0.98	0.94	1.02	0.460
Pre Op Sagittal Cobb	1.01	0.98	1.04	0.613
Pre-Op FVC	0.95	0.90	0.99	0.045***
EBL	0.99	0.99	1.00	0.823
Duration of surgery	0.98	0.96	1.00	0.084
Thoracoplasty	5.19	0.40	67.94	0.209
SPO	0.83	0.10	6.70	0.868
PSO	1			
VCR	1			

*** means significant at 0.05 alpha level.

BMI: Body Mass Index

FVC: Forced vital capacity

EBL: Estimated Blood Loss

SPO: Smith-Peterson Osteotomy

PSO: pedicle subtraction *osteotomy*

VCR: Vertebral Column Resection

Outcomes of Pulmonary Events

The etiologies of the 17 patients who developed pulmonary complications comprised 7 Idiopathic, 5 congenital, 2 Neuromuscular, 2 Neurofibromatosis and 1 Post TB. There were 3 mortalities (1 congenital, 1 Post TB and 1 Neurofibromatosis) representing a case fatality rate of 17.6%. The details of the outcomes of pulmonary events by type of pulmonary event and deformity etiologies are shown in **Table 3** and **Table 4**, respectively.

Table 3: Outcomes of Pulmonary Complications by type of Pulmonary Event

Outcomes of Pulmonary Complications by type of Pulmonary Event			
Pulmonary Event	Frequency	Outcome	
		Recovered	Died
ARDS	1	0	1
Respiratory Failure	1	1	0
left lobar pneumonia	2	2	0
pleural effusion	1	1	0
Pneumothorax	1	1	0
Pulmonary embolism	1	1	0
Pulmonary oedema	2	2	0
Reintubation- Respiratory failure	4	2	2
Tracheostomy	4	4	0
Total	17	14	3
ARDS: Acute respiratory distress syndrome			

Table 4: Outcomes of Pulmonary Complications by Curve Etiologies

Table 4			
Pulmonary Event	Frequency	Outcome	
		Recovered	Died
Idiopathic	7	7	0
Congenital	5	4	1
Post Tuberculous	1	0	1
Neuromuscular	2	2	0
Neurofibromatosis	2	1	1
Total	17	14	3

Discussion

Pulmonary complications are very critical in perioperative management of patients after complex deformity surgery. Despite the variation in definition of pulmonary complications, the conditions classified as such are generally similar and they include Empyema, Haemothorax, Pleural effusion, Post-op hypoxia, Pneumonia, Pneumothorax, Pulmonary embolus, Respiratory arrest, Transfusion-related Acute Lung Injury (TRALI), Transfusion Associated Circulatory Overload (TACO) and pulmonary edema amongst other pulmonary problems [9,19,20,24-26].

The cumulative incidence of post-op pulmonary complication observed in this cohort was 6.16%. This incidence is within the range reported by previous studies [7-12]. Patil et al. [7] reported a post-op

pulmonary complication rate of 8.1% among idiopathic patients <18years (1-17yrs) old and 9.8% in idiopathic patients >18years old (18–84yrs). Imposti et al. [9] also reported a 9% cumulative incidence of a pulmonary complication after spine surgery. Their patients were >18years and comprised degenerative and trauma cases. Moreover, pulmonary complications within 2-year period after spinal surgery were included in their reported cumulative incidence [9]. However, the present study included only paediatric and young adult deformity patients aged 3-25years and reported only early pulmonary complications (up to 6weeks post-op). These methodological variations could account for the slight difference observed in the cumulative incidence of post-op pulmonary complications.

It is already established that complex spine deformity is associated with poor pulmonary function [14-17]. However, the degree of pulmonary compromise is not attributable to curve magnitudes alone [17]. We observed that pre-op FVC (% predicted) was significantly lower in patients who developed pulmonary complications compared to those who had no pulmonary complications. Further analysis with multivariate logistic regression revealed that increasing pre-op FVC was associated with reduced odds of pulmonary complications (OR=0.95, 95% CI 0.90 to 0.99, p=0.035). Spine surgery can cause significant transient decline in PFT up to 60% of pre-op values with a gradual return to baseline 1-2 months after surgery [27]. Therefore, patients with poor baseline PFT may have higher risk for post-op pulmonary complications because they are likely to experience further deterioration in their PFT after spine surgery compared to their counterparts with good baseline PFT. Lao et al. [18] also reported that patients with severe or moderate preoperative pulmonary dysfunction, as measured by the FVC ratio, had a higher incidence of post-op pulmonary complications. Stein et al. [24] also found a higher incidence of pulmonary complications in patients with abnormal PFT results compared to those with normal PFTs. In addition, Kang et al. [25] found that neuromuscular patients with FVC <39.5% have increased risk of post-op pulmonary complications following spine surgery. Preoperative long term Halo gravity traction with breathing exercises may help in this regard.

We report a case-fatality rate of 17.6% among patients who developed post-op pulmonary complications. This highlights the likelihood of an adverse outcome when there is a pulmonary complication. Previous studies have also documented significant mortality following post-op pulmonary complications [5,6,9,26]. Imposti et al. [9] found that mortality rate from pulmonary complications was 3.61 per 1,000 persons per year. Pumberger et al. [26] also assessed the risk factors for in-hospital mortality following lumbar fusion surgery and found that patients who developed post-op pneumonia had 3 times greater risk of mortality while those who developed pulmonary embolism had 10 times greater risk of mortality. The case-fatality rate observed in the present series of paediatric and young adult spine deformity patients underscores the need for proactive perioperative measures to reduce pulmonary complications.

The 6.16% incidence of pulmonary complication recorded in this series is commendable for a private facility in low-resource setting such as Ghana. Various perioperative measures have enabled us to achieve such comparable pulmonary complication rates despite the complexities of the spine deformity cases present in this cohort. These included utilization of pre-op Halo Gravity Traction (HGT) [13,28-29],

adequate pre-op nutritional rehabilitation [30], elective overnight ventilation after surgery for patients with poor FVC and early application of tracheostomy at the earliest sign of difficulty in weaning off ventilation.

Therefore, we make the following recommendations for surgeons performing complex deformity surgery in low-resource settings:

1. Identification of high risk patients with poor pre-op FVC
2. Utilization of HGT to reduce curve magnitude and stiffness
3. Pre-op nutritional optimization
4. Elective post-op ventilation and use of prophylactic diuretics for pulmonary edema
5. Application of Tracheotomy at the earliest sign of respiratory distress
6. Need for ICU coverage

Strengths and Limitations

This paper is the largest single site review of post-operative pulmonary complications following complex spine deformity surgery in Africa. However, as a retrospective study, the study has certain limitations. Analysis and findings were based on only data that could be retrieved. The study reported on early pulmonary complications (up 6weeks post-op) hence it is possible that the complication rate may vary if patients were followed over longer period after surgery. These patients are being followed for long term pulmonary outcomes.

Conclusion

We report a 6.16% cumulative incidence of pulmonary complication in our series which is within the range of other reports. Pre-op FVC was the only significant independent risk factor for pulmonary complications. The high case fatality rate observed (17.6%) implies the need for thorough pre-op evaluation to identify high risk patients and the need for proactive perioperative measures to reduce incidence and mortality associated with pulmonary complications.

List Of Abbreviations

BMI: Body Mass Index

FVC: Forced vital capacity

FEV1: Forced Expiratory Volume in one second (FEV1)

Post-op: Post-operative

Pre-op: Pre-operative

EBL: Estimated Blood Loss

SPO: Smith-Peterson Osteotomy

VCR: Vertebral Column Resection

Post TB: *Post-tubercular*

TRALI: Transfusion-related Acute Lung Injury

TACO: Transfusion Associated Circulatory Overload ()

ARDS: Acute respiratory distress syndrome

HGT: Halo Gravity Traction

IRB: Institutional Review Board

NMIMR: Noguchi Memorial Institute for Medical Research

OR: Odds Ratio

Declarations

Ethics approval and consent to participate

Institutional Review Board (IRB) approval was obtained from the Noguchi Memorial Institute for Medical Research (NMIMR) to use de-identified secondary data from the FOCOS Spine Registry (Certified Protocol Number: 057/16-17 *amend.* 2018). No additional consents were obtained from patients.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

OBA (grants, personal fees and other from K2M, other from WEIGAO, outside the submitted work). For the remaining authors none were declared.

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Authors' contributions

IW, HOD, OBA, GOA, KPY, AOY, HA and the FSRG designed the study. IW, HOD and OBA contributed to the writing of the introduction. HOD, HOT, MAO, HBY, AOY and FSRG contributed to data verification and cleaning. HOD performed the data analysis. IW, HOD, HBY, MAO, KPY, GOA, HA, AOY and HOT contributed to interpretation of statistical results. HOD, IW and OBA contributed to writing the methods section. HOD, IW, and OBA contributed to the writing of the discussion. All authors reviewed the final manuscript. All authors read and approved the final manuscript.

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FSRG is collaborative and multidisciplinary group of researchers who conduct research into the management of complex paediatric and adult spine deformities at the FOCOS Orthopaedic Hospital.

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