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SYMPOSIUM: CHILDHOOD OBESITY AND MUSCULOSKELETAL PROBLEMS

Obesity Negatively Affects Spinal Surgery in Idiopathic Scoliosis

Christina K. Hardesty MD, Connie Poe-Kochert RN, CNP, Jochen P. Son-Hing MD, FRCSC, George H. Thompson MD

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Abstract

Background Are obese patients with idiopathic scoliosis undergoing spinal surgery at higher risk for perioperative complications? This is not clearly understood. One previous study showed a greater preoperative thoracic kyphosis but no increase in perioperative complications.

Questions/purposes We asked whether obese adolescents with idiopathic scoliosis have more perioperative complications and decreased curve correction.

Methods We retrospectively reviewed 478 patients with idiopathic scoliosis operated on from 1998 to 2010. There were 236 (187 females, 49 males) with a mean age of 14 years (range, 11–22 years) who met the inclusion criteria. Demographic data, radiographic measurements, perioperative data, and major and minor complications were recorded. The BMI percentile (BMI%) defined two patient groups: healthy weight (BMI% < 85) ($n = 181$) and obese (BMI% ≥ 85) ($n = 55$). The preoperative curves were similar in the two groups. Minimum followup was 2 years (mean, 6 years; range, 2–14 years).

Results Postoperatively, the mean major curve was smaller for healthy-weight patients (20°; range, 8°–36°) than for obese patients (23.2°; range, 12°–56°), as was the mean kyphosis (31.1° [range, 10°–56°]) versus 36° [range, 15°–33°], respectively). The postoperative lordosis was similar in both groups. Increased BMI% correlated with increased operative time, intraoperative blood loss, amount of intraoperative crystalloids, and difficulty with administration of spinal anesthesia.

Conclusions Obese patients are at higher risk for perioperative complications when undergoing spinal deformity surgery. Counseling should be done with the patient and family and weight loss recommended before surgery.

Level of Evidence Level IV, prognostic study. See Instructions for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

C. K. Hardesty, C. Poe-Kochert, J. P. Son-Hing,
G. H. Thompson (✉)
Division of Pediatric Orthopaedics, Rainbow Babies and Children's Hospital, University Hospitals Case Medical Center, Case Western Reserve University, 11100 Euclid Avenue, Cleveland, OH 44106, USA
e-mail: ght@po.cwru.edu

Introduction

Obesity has become a global epidemic and now affects children as much as adults. One in five Americans are obese, and this estimate is projected to reach 40% by the year 2025 [9, 16]. Obesity is associated with numerous medical comorbidities and contributes to many perioperative complications. The BMI is an individual's body weight (kilograms) divided by the square of the height (meters) [15]. Children and adolescents are evaluated using a BMI percentile (BMI%) that adjusts for the age and sex of the child. This calculation was defined by the CDC to help identify and associate risk factors for increased morbidity and mortality in children [6]. Obesity has been associated with an increased risk for several musculoskeletal conditions in children and adolescents, including slipped capital femoral epiphysis, tibia vara (Blount's disease), genu valgum, and idiopathic scoliosis [2, 4, 11–13, 17]. Obese adults undergoing surgery have demonstrated a higher risk of myocardial infarction, peripheral nerve injuries, wound infections, deep venous thrombosis, and reduced tissue perfusion [1]. Upasani et al. [18] in 2008 reported the only previous study on obesity and the results of surgery for idiopathic scoliosis. This multicenter retrospective review of 241 patients examined the relationship between BMI% and surgical outcomes. Obesity did not increase perioperative morbidity or mortality. Patients considered obese (BMI% ≥ 85) had increased preoperative kyphosis, but the increased BMI did not affect their ability to achieve coronal or sagittal plane correction comparable to that of healthy-weight patients (BMI% < 85). Our single-institution experience suggested different curve measurements and complication rates despite a similar population size. We reviewed our data to analyze perioperative factors, magni-tude and correction of spinal curves, and major and minor complications.

We asked whether patients with an increased BMI% undergoing spinal surgery would have a higher incidence of perioperative morbidity, decreased curve correction, and increased rate of major and minor complications compared to those with a healthy-weight BMI%.

Patients and Methods

We retrospectively reviewed our institutional review board-approved Pediatric Orthopaedic Spine Database. We identified 478 patients with juvenile or adolescent idiopathic scoliosis who underwent a posterior spinal fusion and segmental spinal instrumentation. We excluded 242 patients who did not have adequate height or weight data or incomplete radiographs, did not receive aminocaproic acid during surgery, had a primary diagnosis other than juvenile or adolescent idiopathic scoliosis, had a staged or same-day anterior procedure, and had less than 2 years of postoperative followup or were lost to followup before 2 years. These exclusions left 236 patients (192 females, 44 males) who had surgery between 1998 and 2010. Their mean age at surgery was 14.4 years (range, 11–22 years). There was no difference between sexes in the rate of obesity. The mean ± SD BMI for the entire cohort was 21.6 ± 4.9 kg/m^2. The overall mean BMI% was 58.1 ± 29.5 while the median was 61. We divided the patients in this study into two groups using the same criteria as those used in the study by Upasani et al. [18]: healthy weight (BMI% < 85) and obese (BMI% ≥ 85) (Table 1). This allowed an accurate comparison between the two studies. Using these criteria, 181 patients (77%) had a healthy weight and 55 patients (23%) were obese. The two groups were similar except in height, weight, BMI, and BMI% (Table 1). Minimum followup was 2 years (mean, 6 years; range, 2–14 years). No patients were recalled specifically for this study; all data were obtained from our database.

From our database, we extracted the following preoperative data: age, sex, preoperative height and weight, BMI, BMI%, and other health-related issues, including medical comorbidities, metal allergies, or spinal abnormalities other than scoliosis.

Four observers (CKH, CPK, JSH, GHT) independently evaluated all preoperative standing posteroanterior and lateral spinal radiographs for the following variables: major curve magnitude, thoracic kyphosis (T1–T12), and lumbar lordosis (L1–L5). The measurements were compared and any discrepancies were discussed, with repeat measurements made until a consensus could be obtained. The mean preoperative major curve, thoracic kyphosis, and lumbar lordosis for healthy-weight and obese patients were recorded (Table 1).

All procedures were performed by one of six fellowship-trained pediatric orthopaedic surgeons. We recorded perioperative data, including the type of instrumentation

Table 1. Preoperative clinical and radiographic data

Variable	Healthy-weight patients (BMI% < 85)	Obese patients (BMI% ≥ 85)	p value
Number of patients	181	55	
Number of males	32	12	
Number of females	149	43	
Age (years)*	14.5 ± 1.9 (11–22)	14.0 ± 2.0 (11–20)	
Height (cm)*	162.7 ± 9.2 (140–188)	159.2 ± 12.9 (112–183)	0.03
Weight (kg)*	52.1 ± 9.5 (25–83)	72.9 ± 16.6 (47–136)	< 0.001
BMI (kg/m^2)*	19.6 ± 2.3 (10.1–25.1)	28.6 ± 4.6 (22.3–46.2)	< 0.001
BMI%*	46.6 ± 24.6 (4–84)	93.9 ± 5.3 (85–99)	< 0.001
Preoperative major curve (°)*	53.8 ± 8 (41–85)	54.9 ± 8.3 (40–90)	0.37
Preoperative kyphosis (°)*	33.3 ± 15.4 (−12 to 65)	37.1 ± 15.3 (5–56)	0.19
Preoperative lordosis (°)*	45.4 ± 13.3 (11–92)	46 ± 12.1 (17–68)	0.82

* Values are expressed as mean ± SD, with range in parentheses; BMI% = BMI percentile.

(hybrid or all-pedicle-screw constructs), operative time, amount of intraoperative fluids (crystalloid) administered, estimated intraoperative blood loss, measured postoperative suction drainage, perioperative blood loss, length of hospital stay, amount of intraoperative blood returned (cell saver), total amount of blood transfused perioperatively, and ability to receive intrathecal morphine. As part of our standard protocol, all patients receive intrathecal morphine preoperatively unless they have a history of an adverse reaction to morphine, are physically unable to have a successful lumbar puncture, or the administration is refused by their parents or guardians. All patients had a posterior spinal fusion with segmental spinal instrumentation. Overall, 203 patients had hybrid constructs using distal (lumbar) pedicle screws and proximal (thoracic) hooks while 33 patients had all-pedicle-screw constructs with screws at all instrumented levels (Table 2).

Patients were followed at 1, 5, 12, 18, and 24 months postoperatively and then at 1- to 2-year intervals thereafter, depending on their age at surgery and maturity. At each visit, standing posteroanterior and lateral radiographs were obtained. A physical examination was performed and major or minor complications were documented. All immediate complications related to surgery were classified according to the criteria of Hod-Feins et al. [7]. This classification uses nine categories: respiratory, gastrointestinal, cardiovascular, neurologic, genitourinary, wound, wound infection, instrumentation failure, and curve progression. These are subdivided into major and minor complications (Table 3). Four observers (CKH, CPK, JSH, GHT) independently evaluated all radiographs for the same parameters obtained preoperatively. Any disparity in measurements was reviewed by two observers (CKH, CPK) and a final measurement was documented.

We determined differences in the comorbidities and curve measurements between healthy-weight and obese patients using Student's t-tests, while the complication data were analyzed using Fisher exact tests. We performed data analysis using GraphPad Prism® software (GraphPad Software Inc, La Jolla, CA, USA).

Table 2. Intraoperative and postoperative clinical and radiographic data

Variable	Healthy-weight patients (BMI% < 85) (n = 181)	Obese patients (BMI% ≥ 85) (n = 55)	p value
Hybrid (number of patients)	158	45	
Screws (number of patients)	22	11	
Operative time (minutes)*	293 ± 55 (180–495)	324 ± 78 (210–600)	0.001
Fluids given (mL)*	2757.5 ± 891.9 (750–5500)	3077.2 ± 1092.3 (1400–6200)	0.03
Intraoperative blood loss (mL)*	763.7 ± 368.2 (150–2000)	910.1 ± 410.1 (350–1700)	0.01
Drain output (mL)*	543.5 ± 268.2 (64–1483)	472.0 ± 281.0 (21–1218)	0.09
Length of stay (days)*	4.6 ± 0.7 (3–8)	4.7 ± 0.7 (4–7)	0.35
Cell saver (mL)*	186.4 ± 140.0 (23–800)	208.2 ± 146.2 (35–542)	0.32
Total transfused (mL)*	382.8 ± 288.0 (25–1775)	378.9 ± 281.1 (35–948)	0.93
No intrathecal morphine (number of patients)	3 (0.16%)	5 (10%)	0.02
Number of complications	28 (15%)	8 (14%)	0.95
Postoperative major curve (°)*,†	20 ± 5.7 (8–36)	23.2 ± 9.4 (12–56)	0.004
Postoperative kyphosis (°)*,†	31.1 ± 9.5 (10–56)	36 ± 9.9 (15–53)	0.019
Postoperative lordosis (°)*,†	40.6 ± 10.1 (20–68)	42 ± 12.5 (10–70)	0.513

* Values are expressed as mean ± SD, with range in parentheses; † at latest followup; BMI% = BMI percentile.

Results

Operative time was longer (p = 0.001), more intraoperative crystalloids were given (p = 0.03), intraoperative blood loss was higher (p = 0.01), and the ability to use intrathecal morphine was lower (p = 0.02) in obese patients compared to healthy-weight patients (Table 2). Postoperative suction drainage, length of hospital stay, volume of cell saver blood returned, total amount of blood transfused, and number of complications were similar between groups. At latest followup, in the healthy-weight patients, the mean major curve was 20° ± 5.7° (range, 8°–36°), thoracic kyphosis was 31.1° ± 9.5° (range, 10°–56°), and lumbar lordosis was 40.6° ± 10.1° (range, 20°–68°). In obese patients, these values were 23.2° ± 9.4° (range, 12°–56°), 36° ± 9.9° (range, 15°–53°), and 42° ± 12.5° (range, 10°–70°), respectively. Although the postoperative major curve and kyphosis values were statistically different between groups, the actual differences were judged clinically unimportant.

The complications were also similar between groups (Table 4). There were 29 (16%) complications in the healthy-weight patients and 10 (18%) in the obese patients. No patient had more than one complication. Overall, there were six patients with intraoperative dural tears or leaks

Table 3. Classification of major and minor complications*

Complication category	Major	Minor
Respiratory	Respiratory distress of any cause (significantly low oxygen saturation or prolonged intubation), pneumonia, significant atelectasis (requiring prolonged chest tube)	Asymptomatic pleural effusion, pneumothorax, atelectasis, or lung contusion
Neurologic	Convulsions, motor or sensory deficiencies, prolonged urinary retention	Temperature difference between legs
Hematologic	Continuous bleeding from incisions, venous thrombosis	Asymptomatic coagulopathy or thrombocytopenia
Gastrointestinal	Recurrent gastrointestinal bleeding	Constipation, elevated liver enzymes or bilirubin, nausea or vomiting
Cardiovascular	Hemodynamic instability (defined as systolic pressure < 90 mm Hg combined with clinical parameters of low peripheral perfusion)	Low blood pressure at arrival to the floor, temporary oliguria
Wound/ Infection	Wound infection requiring return to the operating room	Wound resolved with local wound care, urinary tract infection
Instrumentation failure	Required reoperation	Asymptomatic
Curve progression	Required reoperation	Asymptomatic
Miscellaneous	Decubitus ulcer, fever > 39°C	Fever ≤ 39°C

* Modified from Hod-Feins et al. [7].

Table 4. Complications

Complication category*	Number of patients	
	Healthy-weight patients (BMI% < 85) (n = 181)	Obese patients (BMI% ≥ 85) (n = 55)
Respiratory	9	3
Pleural effusion	2	0
Respiratory depression (secondary to morphine)	4	2
Hemothorax	3	1
Gastrointestinal	3	3
Prolonged ileus	1	0
Pancreatitis	0	1
Parotitis	1	0
Clostridium difficile colitis	1	2
Cardiovascular	0	0
Neurologic	5	1
Thumb paresthesia	1	0
Lower leg hyperesthesia	1	0
Dural tear	3	1
Genitourinary	0	0
Wound	3	1
Metal allergy	2	0
Seroma	1	1
Wound infection	8	1
Acute	3	1
Late	5	0
Instrumentation failure	1	1
Hook displacement	1	0
Rod breakage	0	1
Curve progression	0	0
Total	29 (16%)	10 (18%)

* Modified from Hod-Feins et al. [7].

that required closure. Postoperatively, there were 12 patients with respiratory problems, four patients with gastrointestinal abnormalities, two patients with neurologic complications, eight patients with wound infections (four early and five late), two instrumentation complications, and no patients with cardiovascular complications, genitourinary complications, and curve progressions. Overall, 28 complications were classified as major and 11 as minor. There were 22 major complications in the healthy-weight group and six major complications in the obese group. The remaining complications were classified as minor.

The inability to receive intrathecal morphine occurred in eight patients: five in the obese group and three in the healthy-weight group. The body habitus of the obese patients was the major cause, whereas in the healthy-weight patients two of three had increased lumbar rotational deformity and the parents refused intrathecal medication in the other.

Discussion

Many surgeons assume obese patients have a higher risk of surgical complications than healthy-weight patients [5]. Several recent studies provide conflicting results. One Level II study of adults who underwent operative treatment of acetabular fractures demonstrated BMI was predictive of complications [8]. Another study noted severely overweight patients who sustained blunt trauma had higher mortality and complication rates than healthy-weight patients [3]. We asked whether patients with an increased BMI% undergoing spinal surgery for idiopathic scoliosis from a single center would demonstrate a higher incidence of perioperative complications compared to those with a healthy-weight BMI%.

There were several limitations to this study. First, the complications had been recorded by a single individual in a database. Given the study was limited to previously collected data rather than prospectively collected according to a protocol, it could be subject to bias in recording the complications. Second, we had a relatively small sample size, affected primarily by missing data from many of the patients since inclusion required complete data. The small sample size did not allow for control of potentially confounding variables. Third, data from the cases of six surgeons were collected; these surgeons operate at different speeds, have differing perspectives on use of cell saver, and prefer different constructs (hybrid versus all pedicle screws). Additional prospective or larger studies will help elucidate the morbidities to which obese patients are exposed. Such studies will also drive the initiatives to make surgery safer for those children who are obese.

In the multicenter study by Upasani et al. [18] in which 193 healthy-weight (BMI% < 85) patients were compared to 48 obese (BMI% > 85) patients, obese patients had a greater preoperative thoracic kyphosis (T5–T12) than healthy-weight patients. Body mass, however, did not affect their ability to achieve coronal or sagittal plane correction and did not increase intraoperative or postoperative morbidity. Our study from a single center produced somewhat different curve measurements and perioperative complications, although the patient populations in the two studies were similar. We did not find the increase in thoracic kyphosis (T1–T12). In the study by Upasani et al. [18], the mean thoracic kyphosis was 21.8 ± 12.5 in the healthy-weight patients and 27.0 ± 12.6 in the obese patients, whereas our means were 33.3 ± 15.4 and 37.1 ± 15.3, respectively. We encountered increased estimated intraoperative blood loss, longer surgical times, and increased use of crystalloids. The increased operative time logically related to the intraoperative blood loss and crystalloid administration. Interestingly, infection was observed in 4.4% of healthy-weight patients and 1.8% of obese patients. We do not have an explanation for this other than that the small sample size of obese patients likely limited this analysis. We also found being obese compromised the administration of intrathecal morphine. In addition, obesity increased the distance from the skin to the dura and made the palpation of osseous landmarks more difficult. Interestingly, there was no increase in complications, confirming the previous observations of Upasani et al. [18].

One study of morbidly obese adults undergoing nailing of femoral shaft fractures reported difficulty with positioning, long operative times, and a high rate of perioperative complications [14]. Yet, the study of Upasani et al. [18] and ours did not find body mass affected the ability to achieve correction or lead to increased morbidity and mortality.

Idiopathic scoliosis affects about 3% of the healthy-weight juvenile and adolescent population and can usually be treated successfully with orthoses or surgical correction. Orthoses, however, are difficult to mold properly in an obese patient and are not as effective at controlling a curve or preventing progression [10]. These otherwise healthy patients should be limited in the amount of risk they are exposed to when undergoing spinal deformity correction surgery. Increased intraoperative blood loss, longer surgical times, increased use of crystalloids, and decreased ability to use intrathecal analgesia are undesired problems that make surgery more difficult for these patients. In our cohort, prolonged operative time resulted in increased intraoperative blood loss and crystalloid administration. This may result in an increased risk for cardiovascular problems, difficulty with narcotics, and consequently respiratory issues such as pleural effusions. The use of intraoperative crystalloids was higher as well, although possibly related to calculation of BMI and operative time, but fluids should be calculated based on ideal body weight and children can easily be given too much when their body fat percentage is not taken into account. Longer operative times are never ideal and can increase the risk of intraoperative and postoperative complications. Finally, a patient whose body habitus makes it difficult to deliver intrathecal anesthesia will be exposed to much higher doses of systemic narcotics, placing their postoperative course at risk for gastrointestinal problems, increased hospital stays, and possible respiratory depression. On the other hand, obese adolescents are not at increased risk for excessive postoperative drain output, increased length of hospital stay, and increased blood transfusion. Surprisingly, the percentage of postoperative complications was almost equal in both groups. The small sample size made it impossible to identify any difference in complications, but evaluation of a larger population may identify substantial differences between healthy-weight and obese groups. The potential complications of the inability to used intrathecal morphine were not noted in this series but might be noted in a larger series.

In conclusion, this study demonstrated an increased BMI% is associated with increased intraoperative blood loss, longer surgical times, increased use of crystalloids, and decreased ability to use intrathecal analgesia. These findings were relatively similar to a previous multicenter study. The perioperative comorbidities, curve magnitude, and complications, while slightly different in the current study, may have a substantial clinical impact when larger populations are examined. The comorbidities have the potential to increase the technical difficulty of and the complications associated with spinal deformity correction surgery for obese patients with juvenile or adolescent idiopathic scoliosis compared to their healthy-weight peers.

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