Superior mesenteric artery syndrome: A rare complication of scoliosis corrective surgery

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Abstract
Superior mesenteric artery (SMA) syndrome is a rare but serious complication following scoliosis surgery. Early diagnosis and management are key factors for successful conservative treatment to avoid the need for emergency laparotomies which causes higher morbidity or even mortality. We report two adolescent idiopathic scoliosis patients with Cobb angle of 49° and 132°, respectively, and low body mass index who presented with SMA syndrome following posterior spinal fusion from T2 to L3 and were treated successfully with conservative management. Abdominal radiographs showed distended gastric shadow. Computed tomography angiography of the abdomen showed decreased aortomesenteric angle and SMA-aorta distance. Both patients were treated successfully with conservative treatment which included three principles: gastric decompression with nasogastric tube, correction of electrolytes imbalance, and nutritional support with low volume, high calorie nutritional supplement. Both patients were started with small but frequent meals. Surgeries were not required in both cases. Early diagnosis and management are the key factors to successful treatment in SMA syndrome. Patients with SMA can be treated successfully with conservative treatment comprising of nasogastric decompression, electrolyte correction, and nutritional support with small but frequent meals.

Keywords
adolescent idiopathic scoliosis (AIS), aortomesenteric angle, posterior spinal fusion (PSF), SMA-aorta distance, small frequent meals, superior mesenteric artery (SMA) syndrome, vomiting, weight loss

Date received: 5 March 2020; Received revised 4 June 2020; accepted: 6 July 2020

Introduction
Superior mesenteric artery (SMA) syndrome is a rare complication following scoliosis surgery. It is due to vascular compression of the third part of the duodenum between the SMA and the abdominal aorta when the duodenum traverses the aorta in the axilla of SMA.¹⁻⁴ The incidence was reported to be from 0.013% to 4.7%.⁵⁻⁹ Early diagnosis and management should be emphasized as emergent laparotomies which would be required if diagnosis is delayed had a mortality rate of 33%.⁶ We aimed to report two cases of SMA syndrome following posterior spinal fusion (PSF) for
adolescent idiopathic scoliosis (AIS) who were managed successfully with conservative treatment comprising of nasogastric decompression, nutritional support, and correction of electrolytes.

Case presentation

Case 1

A 15-year-old girl with AIS Lenke 6C (left T2–T8, apex T5, Cobb angle: 45°; right T8–L3, apex T12/L1, Cobb angle: 49°, SB Cobb angle: 7°) underwent PSF from T2–L3 level (Figure 1(a) and (b)). Preoperative height, weight, and body mass index (BMI) were 158 cm (27.4th percentile), 41 kg (5.48th percentile), and 16.4 kg/m² (6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 15° and correction rate (CR) was 69.4% (Figure 1(b)). Preoperative height gain was 2.5 cm. She was discharged well on postoperative day (POD) 3. On POD 12, she developed recurrent vomiting. She had weight loss of 4 kg (41–37 kg). Abdominal radiograph showed a distended gastric shadow (white arrows) and fluid level (black arrow). Computed tomography angiography (CTA) confirmed the diagnosis of SMA syndrome (aortomesenteric angle: 10°, SMA-aorta distance: 3.2 mm, and constriction of the third part of the duodenum by the superior mesenteric artery. She was managed conservatively with correction of electrolyte imbalances and nutritional support with small, frequent meals. Low volume but high calorie nutritional supplements were added. She was discharged after 12 days. She had complete resolution of symptoms on POD 35 and regained her preoperative weight (41 kg) at 12 weeks.

Case 2

A 16-year-old girl presented with severe AIS Lenke 2AR (left T2–T6, apex T4, Cobb angle: 83°, SB Cobb angle: 59°; right T6–L2, apex T10, Cobb angle: 132°, SB Cobb angle: 97°; left L2–L5, apex L5, Cobb angle: 57°, SB Cobb angle: 8°) underwent PSF from T2–L3 level (Figure 2(a) and (b)). Preoperative height, weight, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)). Preoperative weight, height, and BMI were 161 cm (40.5th percentile), 42.3 kg (3.75th percentile), and 16.3 kg/m² (2.6th percentile), respectively. The surgery was uneventful. Postoperative Cobb angle was 63° and CR was 52.3% (Figure 2(b)).
and SMA-aorta distance of 2.6 mm (Figure 2(f) and (g)). She was also treated conservatively with similar protocols mentioned above. As her condition was more severe, her treatment regime was slightly different. She was kept nil per oral for 5 days and was given clear fluids once nausea and vomiting resolved. Total parenteral nutrition was then administered. On POD 21, nourishing fluid was started. On POD 26, she resumed normal diet.

**Discussion**

Symptoms of SMA syndrome usually occur after 5–7 days following scoliosis surgery. The patients often presented with persistent, recurrent vomiting in addition to abdominal distension and epigastric tenderness. Postoperative paralytic ileus secondary to general anesthesia, analgesia, or electrolyte imbalance often develop earlier in the postoperative period and resolve spontaneously in 3–5 days. In this case report, both patients presented with persistent, recurrent vomiting 1 week after scoliosis surgery (POD 12 in case 1 and POD 7 in case 2). Delayed onset of persistent, recurrent vomiting following scoliosis surgery should raise suspicion of SMA syndrome especially in higher risk patients. In the plain radiographs of the abdomen, the classical sign indicates gas in the distended stomach and in the dilated proximal duodenum with air-fluid levels. In scoliosis patients following surgery, the presence of this sign should raise the suspicion of SMA syndrome.

Identifying patients at risk for SMA syndrome is important. Risk factors are staged procedures, lumbar modifier of B and C, height >50th percentile, weight <25th percentile, BMI <25th percentile, sagittal kyphosis, increased thoracic rigidity, and acute spinal lengthening. Zhu and Qiu reported seven cases of SMA syndrome in their series of 640 scoliosis patients following surgery. Among them, four cases had thoracic hyperkyphosis and two had thoracolumbar kyphosis. Braun et al., in a case–control study comparing 17 patients with SMA syndrome and 34 control subjects, reported a higher percentage of patients with positive thoracic kyphosis (based on Lenke classification) in the group with SMA syndrome (23.5%) than in the control group (14.3%) \((p = 0.07)\). Patients with increased thoracic curve rigidity (<60% SB flexibility) had an odds ratio of 6.67 of developing SMA syndrome following scoliosis surgery \((p = 0.006)\). Both patients had risk factors, that is, increased height but low weight for age and low BMI, although BMI of around 16 kg/m\(^2\) was not particularly low for the Asian population. Case 1 had a long thoracolumbar curve which could probably be a risk factor for SMA syndrome because correction of a long curve may predispose the viscera to more stretching. The second patient had 7.5 cm lengthening.
| Study          | Year | Patient profile | POD  | Type of curve | Surgical procedure | Postoperative Cobb's angle | Presentation | Investigation | Treatment and outcome                        |
|---------------|------|----------------|------|---------------|-------------------|---------------------------|--------------|--------------|---------------------------------------------|
| Kennedy et al.24 | 1983 | 14/M Thin       | 40   | Thoracic 73°  | PSF               | 54°                       | Vomiting, circulatory collapse | Diagnosis made at autopsy | Total gastrectomy with esophagojejunal anastomosis |
| Amy et al.23   | 1985 | 16             | 16   | T4–T11: 54°   | PSF T4–L1         | N/A                       | Vomiting, abdominal pain      | UGI           | Ladd procedure                              |
| Moskovich et al.21 | 1986 | 16.5/F         | 9    | T5–T12: 65°   | PSF T4–L3         | 21°                       | Bilious vomiting              | UGI           | Duodenojunostomy                            |
| Tsirikos et al.5 | 2005 | 14/F 38.5 kg   | 6    | T12–L4: 52°   | Anterior-posterior fusion T4–L1 | 15°, 22°                 | Distended abdomen, abdominal pain, vomiting | UGI           | Nasojejunal tube feeding                    |
| Pan et al.14    | 2007 | 12/F 15.6 kg, 127 cm | 3    | T4–L1: 83°    | Two-staged surgery (ASF T7–T11 and PSF T3-L3) | 48°, 15°                 | Abdominal pain, distended abdomen | NG aspirate ( bile-stained) AUS Serum amylase and lipase | Conservative treatment, nasogastric tube decompression |
| Smith et al.18  | 2009 | 13/F 39.9 kg, 155 cm BMI 16.6 | 7    | T3–T10: 42°   | PSF               | N/A                       | Vomiting, anorexia             | None (clinical diagnosis) | Nasojejunal tube feeding                    |
| Lam et al.13    | 2014 | 12/F 42.8 kg, 165.3 cm BMI 15.1 | 10   | T1–T5: 34°    | PSF T3–L1         | N/A                       | Vomiting, anorexia             | None (clinical diagnosis) | Nasojejunal tube feeding                    |
|                |      | 16/M 44.1 kg, 157.1 cm  | 6    | Lenke 2AN     | PSF T5–L3         | T8–L1: 7°                 | Nausea, vomiting               | None (clinical diagnosis) | Nasojejunal tube feeding                    |
|                |      |                |      | T6–T12: 45°   | PSF T4–L3         | T6–T12: 9°                 | Bilious vomiting, LOW          | UGI           | Nasojejunal tube feeding; 1 week Oral liquid diet: 1 week Soft diet: 1 week |
|                |      |                |      | T12–L4: 2°    |                  | T12–L4: 2°                 | Bilious vomiting, LOW          | UGI           | Nasojejunal tube feeding; 1 week Oral liquid diet: 1 week Soft diet: 1 week |
|                |      |                |      | Lenke 2CN     |                  | T7–T12: 6°                 | Bilious vomiting, LOW          | UGI           | Nasojejunal tube feeding; 1 week Oral liquid diet: 1 week Soft diet: 1 week |
|                |      |                |      | T12–L4: 21°   |                  | T12–L4: 5°                 | Bilious vomiting, abdominal pain, LOW | UGI           | Nasojejunal tube feeding; 1 week Oral liquid diet: 1 week Soft diet: 1 week |

(continued)
| Study                  | Year | Patient profile | POD | Type of curve | Surgical procedure | Postoperative Cobb's angle | Presentation                        | Investigation     | Treatment and outcome                                      |
|-----------------------|------|-----------------|-----|---------------|--------------------|---------------------------|-----------------------------|------------------|-----------------------------------------------------------|
| Keskin et al.\(^{22}\) | 2014 | 17/F            | 5   | Thoracic: 50° | PSF T3–L3          | Complete resolution of spinal curvature | Vomiting, abdominal distension, LOW | Contrast-enhanced CT | Nasogastric decompression, duodenojunostomy               |
|                       |      |                 |     | Lumbar 49°    |                    |                           |                             |                  |                                                           |
| Oyoun et al.\(^{16}\) | 2015 | 12/F            | 4 years | Lumbar 49° | PSF                | N/A                        | LOW                         | UGI              | Nutritional diet up to 2000–3000 cal/day                 |
|                       |      |                 |     |               |                    |                           |                             |                  |                                                           |
| Present study         | 2020 | 15/F            | 12  | Lenke 6C      | PSF T2–L3          | T8–L3: 15°                | Recurrent vomiting, LOW     | CTA              | Small, frequent meals—Nutritional supplementation—low volume high calorie |
|                       |      |                 |     | T8–L3: 49°    |                    |                           |                             |                  |                                                           |
|                       |      |                 | 7   | Lenke 2AR     | PSF T2–L3          | T6-L2: 63°                | Recurrent vomiting, abdominal distension, LOW | CTA              | Nasogastric decompression, Small, frequent meals Nutritional supplementation—low volume high calorie |
|                       |      |                 |     | T6-L2: 132°   |                    |                           |                             |                  |                                                           |

M: male; F: female; N/A: not applicable; UGI: upper gastrointestinal imaging; AUS: abdominal ultrasound; PSF: posterior spinal fusion; ASF: anterior spinal fusion; NG: nasogastric; TPN: total parenteral nutrition; LOW: loss of weight; BMI: body mass index; CTA: computed tomography angiography.
after correction. In addition, the patient also had a rigid thoracic curve (SB flexibility of 26.5%) which may also predispose to SMA syndrome after scoliosis surgery.

The literature review on SMA syndrome following scoliosis surgery is illustrated in Table 1. Most patients can be treated conservatively based on three principles, that is, gastric decompression, electrolyte correction, and nutritional support. Tsirikos et al. proposed oral restriction and commencement of nasojejunal feeding. Mandarry et al. suggested frequent meals of pureed or blenderized food about 180–240 ml given four hourly. Lam et al. proposed a treatment algorithm in managing SMA syndrome following AIS surgery. Our patients had low volume but high calorie supplements.

Failure of conservative treatment might result in life-threatening conditions such as metabolic alkalosis, electrolyte imbalance, and aspiration pneumonia. Surgery such as gastrojejunostomy, duodenoejunostomy, Ladd procedure, and total gastrectomy with esophagojejunal anastomosis may be required. Our patients had responded well to conservative management and no additional surgeries were required. They eventually achieved good weight gain with the treatment regime.

Conclusion

Early diagnosis and management are key factors to successful treatment in SMA syndrome. We report two patients who were treated successfully with conservative treatment comprising of nasogastric decompression, electrolyte correction, and nutritional support with small and frequent meals.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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