Superior mesenteric artery syndrome

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Background. An obstruction of the distal part of the duodenum can occur because of the superior mesenteric artery syndrome (SMAS) after a surgical correction of scoliosis. It is essential to evaluate the risk factors and diagnose the SMAS in time because complications of this condition are life-threatening and it is associated with a high rate of morbidity. Diagnostics of the SMAS is challenging, because it is rare and its symptoms are non-specific. Therefore, in order to better understand the essence of this pathology and to make diagnosis easier we present a rare clinical case of the superior mesenteric artery syndrome after a surgical correction of neuromuscular scoliosis.

The clinical case. A 12-year-old girl with a specific development disorder, sensory neuropathy and progressive kypho-scoliosis was admitted to Vilnius University Children’s Hospital. The patient had right side 50-degree thoracic scoliosis and an 80-degree thoracic kyphosis. She underwent posterior spinal fusion with hooks and screws from Th1 to L2. On the fourth day after the surgery the patient developed nausea and began to vomit each day 1-2 times per day, especially after meals. The SMAS was suspected and a nasogastric tube was inserted, stomach decompression and the correction of electrolytes disbalance were made. After the treatment, the symptoms did not recur and a satisfactory correction and balance of the spine were made in coronal and sagittal planes.

Conclusions. It is extremely important to identify the risk factors of the SMAS and begin preoperative diet supplements before surgical correction of scoliosis for patients with a low body mass index. After the first episode of vomiting following the surgery, we recommend to investigate these patients for a gastrointestinal obstruction as soon as possible. Decompression of the stomach, enteral or parenteral nutrition, and fluid therapy are essential in treating the SMAS.

Keywords: superior mesenteric artery, scoliosis, aortomesenteric angle, abdominal discomfort

INTRODUCTION

The superior mesenteric artery syndrome (SMAS) is rare. However, it is a life threatening condition which occurs when the abdominal aorta and the superior mesenteric artery compress the distal part of the duodenum. It was first described in 1842 by the Austrian physician Rokitansky. The SMAS appears after spine surgeries or surgical treatment of scoliosis. The rate of the SMAS varies from 0.5 to 2.4% (1–3).

The superior mesenteric artery (SMA) rises from the anterior surface of the abdominal aorta,
just inferior to the origin of the celiac trunk at the level of L1 or L2 vertebra. It is covered in adipose and lymphatic tissue; initially it travels in an anterior/inferior direction and enters the small intestine tether (Fig. 1). The mean angle between the abdominal aorta and the SMA is from 38 to 56 degrees, and the distance between these blood vessels is from 10 to 28 mm (4). The SMAS appears because of the reduced aortomesenteric angle (6 to 16 degrees and distance from 2 to 8 mm) (4).

The SMAS can be caused by: fast body mass loss, some metabolic conditions which reduces mesenteric and retroperitoneal adiposal tissue amount, trauma, high anchoring of Treitz ligament, low anchoring of the mesenteric artery, a high-degree lumbar lordosis, neoplastic masses near SMA radix, a dissecting aortic aneurysm and some types of surgeries (5). A surgical correction of scoliosis is one of the most common causes of the SMAS. An asthenic body composition, kyphosis in the sagittal plane, a low body mass index, loss of body mass after surgery are risk factors for the developing SMAS after a surgical treatment of scoliosis (1, 2, 6). Earlier studies showed that if the percentiles of the weight in relation to sex and age are lower than 25, then the risk of developing SMAS is higher (2, 7).

Moreover, the changes in spinal column curvature in coronary and sagittal planes play an important role in the SMAS development. A higher correction causes an increase in the patient's height. Also, an older study shows that flexibility of the kyphotic curvature, the degree of scoliosis and spine balance are very important prognostic factors for developing the SMAS. A surgical correction of scoliosis significantly elongates the spinal column and increases external compression of the distal duodenum as the distal duodenum goes through a tapered angle which is formed of the aorta, the anterior wall of the spinal column, and the posterior wall of the superior mesenteric artery. Due to scoliosis correction surgery, lateral mobility of the SMA is decreased and so the aorto-mesenteric angle is changed. It is observed that the elongation of the spinal column, especially in the lumbar region, after the surgery is an important risk factor for developing the SMAS (6, 8).

Patients with the SMAS usually complain of acute or chronic (depending on the etiology of the SMAS or the degree of duodenum compression) abdominal pain. In both cases, there is a proximal small intestine obstruction. Patients with mild obstruction complain of pain in the epigastric region and early sensation of fullness after meals, whereas if the obstruction is severe patients complain of vomiting, vomiting bile and losing body mass that cannot be explained by any other causes (9, 10). During a physical examination such non-specific findings as abdominal tenderness and high frequency intestinal sounds could be observed. Lam et al. study described 14 patients with SMAS symptoms and evaluated their significance (Table 1) (11). Results of laboratory tests are usually within the normal ranges, only in the cases with severe vomiting a disbalance of electrolytes might be seen. Abdominal pain is one

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**Fig. 1. Anatomy of the superior mesenteric artery syndrome**
of the most common complaints of the patients who underwent surgical treatment of scoliosis. If the SMAS occurs, it usually develops one week after the surgery (1, 12).

Patients with a suspected SMAS must be thoroughly examined using radiographic tests to confirm or exclude the diagnosis. Computed tomography (CT), CT angiography, magnetic resonance imaging (MRI), MRI angiography, conventional angiography, sonoscopy and endoscopic diagnostic tests are used to diagnose the SMAS (13, 14). In the past, angiography was the gold standard for measuring the aortomesenteric angle and the distance between these two vessels. The traditional diagnostic test with barium still plays an important role in the diagnostics of the SMAS and it can be used to visualize the common, but non-specific image: the dilated proximal duodenum with break-up of barium in the distal third of the duodenum (Fig. 2) (15). In several studies, strict radiological criteria were published: dilatation of the first and second thirds of the duodenum with or without dilatation of the stomach, vertical or oblique compression of mucosal ridges, an anti-peristaltic contrast flow towards the obstruction, evacuation of the contrast from the gastroduodenal region prolonged by 4–6 hours (16).

The aortomesenteric angle, the distance between the abdominal aorta and the SMA, the adiposal tissue, the obstruction of the duodenum and a possible cause of compression can be seen in CT images. Moreover, CT could be used to exclude other pathologies and diseases, to visualize the dilation of the duodenum, the anatomy of the SMA and its relation with other blood vessels. Lippl et al. have found that CT with contrast and MRI angiography are equally good for evaluating the aortomesenteric angle and distance (13). As these tests are non-invasive and can give a lot of anatomical information, nowadays they are considered to be the most valuable tests for diagnosing the SMAS. Now, the diagnostic criteria of the SMAS are the following:

- An obstruction of the duodenum with active peristalsis and sudden break-up of contrast in the distal third of the duodenum
- The aortomesenteric angle less than 25 degrees (it is the most sensitive factor, especially if the aortomesenteric distance is less than 8 mm or there is high anchoring of Treitz ligament or low position of the SMA) (4, 14).

A sonoscopy with a doppler can be used to find a reduced aortomesenteric angle (4). Also, during this test the position of the patient could be changed as it could help to recognize any changes

![Fig. 2. Fluoroscopy of the duodenum with barium](image-url)
of the aortomesenteric angle while changing body positions (14). Moreover, an endoscopy of the upper gastrointestinal tract can help to eliminate an intestinal obstruction, a gastric or duodenal ulcer, all of which could manifest as symptoms similar to the SMAS.

Table 1. Symptoms of the SMAS

| Symptoms                        | Number of patients (%) |
|---------------------------------|------------------------|
| Any type of vomiting            | 13 (92.9)              |
| Abdominal pain/sensitivity      | 8 (57.1)               |
| Abdominal tenderness            | 6 (42.9)               |
| Vomiting bile                   | 5 (35.7)               |
| Hypoactive peristaltic movement | 4 (28.6)               |
| Anorexia                        | 3 (21.4)               |

Treatment of the SMAS is usually started with conservative means. The main principles for treating the SMAS are: rehidration, elimination of obstruction, and maintenance of an optimal body weight. If the progression of the symptoms is sudden, a nasogastric tube for gastric and duodenum decompression, positioning of the patient (on abdomen or left side of the body with knees bend to chest) could be an effective part of treatment (16). The described specific compulsory position releases tension on the SMA and increases the space between the aorta and the SMA. It is necessary to recover the balance of fluids and electrolytes as profuse vomiting can be the cause of hypovolemia, hypokalemia, or even metabolic alcalosis. Furthermore, enteral or parenteral nutrition is needed to maintain and increase the body mass. It is important, because the increase of the retroperitonial adiposal tissue increases the aortomesenteric angle. Enteral nutrition with a nasogastric tube situated distally to the obstruction site is preferred. A recent study showed a positive response to non-surgical treatment as symptoms of 86% of the patients improved (9). Most of the patients with the SMAS that developed after surgical treatment of scoliosis made a full recovery after conservative treatment (1).

When symptoms do not improve while treating conservatively, surgical treatment is suggested (17, 18). Surgical treatment of the SMAS involves: gastrojejunostomy, duodenojejunostomy, lysis of Treitz ligament, or the surgical method of Strong. Previously, open duodejejunostomy was the gold standard as it was then the most successful and the safest surgical intervention. However, there is an even better alternative nowadays – a minimally invasive laparoscopic duodenojejunostomy (19). Gastrojejunostomy ensures adequate decompression but the obstruction is not always eliminated. Consequently, the symptoms can persist because the obstruction can cause ulcers and bile reflux. During Strong’s surgery, Treitz ligament is separated, then the transverse and ascendant parts of the duodenum are mobilized. The duodenum is drawn to the right of side of the SMA. However, if there are numerous adhesions the procedure becomes very hard or even impossible to perform.

Due to a high risk of complications and relatively high mortality, it is essential to assess risk factors for the developing SMAS and to diagnose or exclude the diagnosis of the SMAS as soon as possible. Since many physicians are not aware of this syndrome due to its rarity, the SMAS is diagnosed just after a long period of time while a patient is suffering from abdominal pain or discomfort. Late diagnosis can end in complications: death because of the disbalance of electrolytes, a perforation of the stomach, gastric pneumatosis or obstruction caused by duodenum benzoar. Because of the rarity of the SMAS and its non-specific symptoms, diagnostics of this syndrome is a really big diagnostic challenge for physicians. Therefore, to better understand the risk factors of the SMAS and to facilitate diagnostics, we present a recent clinical situation during which the SMAS developed after the surgical treatment of neuromuscular scoliosis.

The clinical case

A 12-year-old girl with mixed specific developmental disorder and sensory neuropathy was hospitalized in the Vilnius University Children’s Hospital for progressive neuromuscular kyphoscoliosis. The patient had not been treated surgically before. At the time of arrival, her weight was 38 kilograms and her height was 150 centimetres. The weight and height were both at the 40th percentile according to age and gender. The body mass index was 16.89 kg/m². There was no family history of gastrointestinal tract diseases.

The patient had right thoracic scoliosis from Th1 vertebra to L2 vertebra. The Cobb angle in the radiograph was 55 degrees, and kyphosis of the thoracic region was 80 degrees (Figs. 3, 4).
The patient’s gait was impaired as she was dragging her feet. Clinically, obvious kyphoscoliosis with the costal hump of 3 cm was seen. Her heels were in valgus deformation. Blood tests taken before the surgery showed no pathology. A whole spine MRT was performed and showed no other abnormalities except kyphoscoliosis.

Posterior spondylodesis with screws and hooks at Th1-L2 level using Expedium implants was performed. Facet joints were removed at Th2-L2 level, ligamenta flava were removed from the region of spondilodesis. Th1 vertebra was fixed with hooks, and all the other vertebrae were fixed with pedicular screws. Shevron type osteotomy was performed at the apex of kyphosis. Further, two rods were mounted, and compression and distraction at the corresponding segments and decortication with high-speed burr were performed. Bone autografts were added to the site of decortication, the wound was closed layer-by-layer and one drain was left. The duration of the whole surgery was five hours during which 300 ml of blood were lost. Haemoglobin, saturation and blood pH were within the normal range. Results of the correction were satisfying: after the surgery, the Cobb angle was 24 degrees, and coronal and sagittal balances were fully recovered.

At first, postoperative care was not complicated and during the first day the patient began to eat. Three days after the surgery, the drain was removed and the thoracolumbar brace was put on for better spine balance. During the fourth day, the patient became nauseous and later started vomiting 1 to 2 times per day, usually after meals. The brace was removed to take a closer look: the abdomen was soft without any tenderness, a bit sensitive in the epigastric region, peristalsis was normal while auscultating. Hypokalemia and metabolic alkalosis were found in blood tests. Gastric decompression with a nasogastric tube for 2 days and correction of electrolytes with intravenous fluids were performed because of a suspected SMAS. After the treatment, the condition of our patient improved and she started to eat on her own again. The patient was discharged 24 days after the surgery, a consultation of a gastroenterologist was recommended. After one month she came back for a consultation of an orthopaedist: symptoms of the SMAS during that period did not recur and the balance of the spine was satisfying.
DISCUSSION

Postoperative sickness and vomiting are not very rare phenomena in children after long surgeries, thus physicians often do not evaluate these symptoms correctly as they are not very specific. For example, vomiting and sickness can occur because of the postoperative consumption of opioid drugs used to relieve pain. For patients who undergo posterior spondylodesis, sickness and vomiting can occur because of postoperative ileus and late mobilization, or because of both of these causes (11). Known causes of postoperative ileus include general anaesthesia, analgesics, electrolytic disbalance, and injury of the greater splanchnic nerve. Postoperative ileus typically manifests itself on day 1 after the surgery and resolves between the 3rd and the 5th days thereafter (15). Distinguishing postoperative ileus from a mechanical small bowel obstruction is of a critical importance. Although both can initially be managed conservatively with bowel rest, a prolonged or worsening small bowel obstruction ultimately requires surgery to prevent intestinal ischemia, necrosis, perforation, and subsequent peritonitis and sepsis. However, clinical differentiation is difficult given the common set of symptoms and signs that the conditions share (11). We recommend prompt radiological evaluation once the diagnosis of gastrointestinal obstruction is made (11).

Therefore, recognizing a child at risk of developing the SMAS following a posterior spinal instrumentation can be a challenge. An asthenic body structure, kyphosis in the sagittal plane, a low body mass index are the risk factors of developing the SMAS after surgical treatment of scoliosis. Some authors conclude that an increase in the body mass before the surgery can lower the chance of developing the SMAS (3). Our patient had all of these risk factors, and, as she developed postoperative vomiting, the SMAS was consequently suspected. Recent studies show that the aortomesenteric angle correlates with the body mass index (22). Kim et al. (23) found during their study that percentile of the body mass according to gender and age helps to foresee the SMAS better than the body mass index alone. Nowadays, it is possible that known risk factors could be indicators of severity of the SMAS. However, more studies should be carried out to confirm that.

In our case, the patient started vomiting during the fourth day after the surgery. According to...
literature, the SMAS most often develops during the first week after the surgery, which coincides with our case. Moreover, the patient's symptoms were relieved by compulsory position (lying on the left side, knees bent to chest). Disbalance of electrolytes was found while analysing blood. On the basis of the symptoms and risk factors, the SMAS was suspected. However, treatment was started immediately and no radiograph was taken before that, although studies recommend to perform abdominal radiograph with barium contrast first (24, 25).

The condition of the patient improved significantly after gastric decompression with a nasogastric tube and a correction of electrolyte imbalance. A considerable loss of the body mass is observed in patients with the SMAS, but body mass of our patient was intact because of early treatment.

Lam et al. (11) described 14 cases of the SMAS after surgical treatment of scoliosis. Three of these cases were analysed. They assessed clinical symptoms and presented the algorithm how to diagnose and treat the SMAS (Fig. 7). One of the patients had no

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**Fig. 7.** The algorithm of the diagnosis and treatment of the SMAS (NGT – nasogastric tube, NJT – nasojejunal tube)
clinical symptoms until discharge thus he suffered
from anorexia and low nutrition. The patient came
back to hospital on the 27th day after the surgery
because of recurrent vomiting which began on
the 13th day. In other study, Tsirikos et al. (26) de-
scribed a clinical case in which postoperative care
was not complicated and even during the first day
the patient began to eat normally. After the sched-
uled treatment, she was discharged although her
body mass was lower than the 20th percentile.
A high nutritional value diet was recommend-
ed to the patient. She was hospitalised because
of sickness and constant vomiting 45 days after
the surgery. She was dehydrated with oliguria and
disbalance of electrolytes, and her body mass de-
creased by 7 kilograms and was lower than the 3rd
percentile. An abdominal radiograph with barium
contrast was taken and the diagnosis of the SMAS
was established. Examples of such a late onset of
symptoms have also been described in other stud-
ies (27). It is possible that before discharge pa-
tients had already had some degree of proximal
duodenum obstruction which was not suspected,
and with the decrease of the body mass the ob-
struction increased and caused the symptoms.
This just confirms how important it is to suspect
and diagnose the SMAS. Parents should also be
informed about possible symptoms of the SMAS:
loss of the body weight, abdominal pain, vomiting
before discharge from hospital.

Frequently, symptoms of the SMAS create a vi-
cious circle: food is not tolerated, then the body
weight is lost, and as a result the aortomesenter-
ic angle decreases, the duodenum is compressed
even more, and it is followed by sickness and vom-
itig. The aim of treating the SMAS is to break this
circle.

The SMAS is often more acute in children than
in adults; also, conservative treatment is often more
successful for children (9). The course of disease is
usually more chronic in adults and surgical treat-
ment is more effective for them as well (28). In our
clinical case, the symptoms of the patient improved
significantly after conservative treatment. We per-
formed gastric decompression with a nasogastric
tube for two days. However, nasojejunal enteral nu-
trition, or even parenteral nutrition, is necessary in
more severe cases to obtain the required level of nu-
trition (5). A patient can return to eating normally
when his or her condition is improved and the com-
pression of the duodenum is decreased. Of course, if
the body mass is low, high in calories nutritious food
is prescribed.

Although the incidence of the SMA syndrome af-
after scoliosis surgery is generally low (1–4.7%) (2, 3, 7,
12), it is associated with significant morbidity. Hence,
there should be a high index of suspicion, especially
for high-risk patients. Classically, the symptoms of
the condition include nausea, bilious vomiting or
increased bilious nasogastric aspirates, postprandial
abdominal distension, and epigastric pain. However,
the diagnosis of the SMA syndrome may not be easy,
given the common clinical symptoms that it shares
with several other conditions.

CONCLUSIONS

It is necessary to identify risk factors for the SMAS
before surgical treatment of scoliosis for patients,
especially those with a low body mass index. While
diagnostics of the SMAS is difficult as the symp-
toms are non-specific and the syndrome itself is
rare, it is essential to recognise the “red flags” after
the surgery and to observe body mass of a patient.

The most common symptoms of the SMAS are
abdominal pain, vomiting episodes, and abdomi-
nal tenderness. We suggest testing for gastrointes-
tinal obstruction immediately if vomiting starts
after surgery. An abdominal x-ray with barium
contrast should be the first choice test for patients
with vomiting episodes. The SMAS can develop up
to one month after surgical treatment of scoliosis,
so if there are symptoms of a gastrointestinal ob-
struction, the SMAS must be included as a possible
cause.

Gastric decompression, enteral or parenteral nu-
trition, and infusion therapy comprise emergency
treatment for the SMAS. If the condition does not
improve over one week, surgical treatment is recom-
mended. Surgical methods of SMAS treatment in-
clude: Strong surgery, gastrojejunostomy, or duode-
nojejunostomy. A delay in using surgical treatment
can increase mortality rates because of malnutrition
and a disbalance of electrolytes. Duodenojejunosti-
omy has shown best results so far. When the SMAS
is diagnosed too late or not diagnosed at all, life-
threatening complications can appear.

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VIRŠUTINĖS PASAITO ARTERIJOS SINDROMAS

Santrauka

Įžanga ir tikslas. Po chirurginės skoliozės korekcijos gali išsivystyti dyvlikaprištes žarnos obstrukcija dėl viršutinės pasaito arterijos sindromas (VPAS). Dėl gresiančių komplikacijų ir santykinių didelio mirštamumo itin svarbu laiku diagnozuoti arba atmesti viršutinės pasaito arterijos sindromą ir įvertinti rizikos veiksnius sindromui išsivystyti. Šio sindromo retumas ir nespecifiniai simptomai – tikras diagnostinis išsūkis gydytojams. Todėl siekiant geriau suprasti ligos esmę, išsiaiškinti rizikos veiksnius ir palengvinti diagnostiką, darbe aprašoma neseniai įvykusį ir reta klinikinė situacija, kurios metu išsivystė viršutinės pasaito arterijos sindromos po neuroraumeninės skoliozės korekcijos.

Klinikinis atvejis. 12 metų mergaitė su specifiniu mišriu raides sutrikimu ir sensorine neuropatija atvyko į Vilniaus universiteto vaikų ligoninę dėl progresuojančios neuroraumeninės kifoskoliozės. Tiriamai pacientei išsivystė dešinioji krūtinė 50 laipsnių skoliozė ir 80 laipsnių kifozė. Pacientei atlikta nugarinė spondylodėzė sraigtas ir kabliukais Th1-L2 lygyje. Ketvirtą parą po operacijos mergaitę pradėjo pykinti, ji pradėjo vemti kiekvieną dieną po 1–2 kartus, dažniausiai pavalgius. Įtarus viršutinės pasaito arterijos sindromą, atlikta skrandžio dekompresija, 2 dienas įvietas nazogastrinis zondas ir koreguotas elektrolitų disbalansas. VPAS būdingi simptomai nesikartojė, ir buvo pasiekta patenkiama stuburo korekcija bei balansas.

Išvados. Būtina identifikuoti viršutinės pasaito arterijos sindromui būdingus rizikos veiksnius ir pradėti priešoperacinę dietą pacientams su maža kūno masės indeksu, kuriems planuojama atlikti chirurginę skoliozės korekciją. Atsiminkime, kad šie pacientai būtų nedelsiant patiškinti dėl virškinamojo trakto obstrukcijos. Skrandžio dekompresija, enterinis arba parenterinis maitinimas, skysčių terapija yra būtinos priemonės gydydamai VPAS.

Raktažodžiai: viršutinė pasaito arterija, skoliozė, aortomezerinis kampas, pilvo diskomfortas