Case Report

Cerebral Fat Embolism Syndrome Following Urgent Debridement and Application of Skeletal Traction for the Right Femur: A Case Report

Mingkwan Wongyingsinn MD*, Direk Tantigate MD**,
Theerapol Witthiwej MD***, Orasa Chawalparit MD****

** Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*
*** Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*
**** Division of Neurosurgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*
***** Division of diagnosis, Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*

Background: *The incidence of fat embolism syndrome (FES) can be found in 3 to 4% of patients who have major trauma, especially with long-bone fractures.*
Objective: *To describe a healthy patient with manifestations of FES following urgent debridement and application of skeletal traction for the femur and review the diagnosis, investigation and management of this condition.*
Case Report: *A healthy 23-year-old man was injured in a motorcycle accident and underwent urgent debridement of the open tibia fracture and application of skeletal traction for the right femur. After one hour of surgery; the patient was suddenly agitated, developed a generalized tonic-clonic seizure and progressed into a coma with the GCS of 6. Petechial skin rash was noted on the anterior chest. The magnetic resonance imaging (MRI) of the brain at postoperative 24 hours provided a confirmation of clinical suspicious of cerebral FES. His postoperative course showed gradual improvement with a slowly resolving encephalopathy in the period of four months.*
Conclusion: *FES is a known complication of long bone trauma and a clinical diagnosis characterized with respiratory insufficiency, neurologic impairment and a petechial rash. MRI of the brain can be used to confirm the diagnosis. Supportive care is the mainstay of therapy for clinically apparent FES.*

Keywords: *Fat embolism syndrome, Cerebral fat embolism syndrome*

J Med Assoc Thai 2017; 100 (Suppl. 2): S170-S175
Full text. e-Journal: *http://www.jmatonline.com*

Fat embolism syndrome (FES) is one of life threatening complications following long bone trauma and orthopedic surgery with intramedullary manipulation. This syndrome typically occurs 8 to 72 hours after trauma or surgery and is characterized by respiratory failure, neurologic dysfunction and petechial rash[1-4]. The clinical presentation of FES varies greatly, however a diagnosis may be difficult particularly in the postoperative period. The authors describe a healthy patient with clinical manifestations of FES in the perioperative period following urgent debridement of the open right tibia fracture and skeletal traction for the right distal femur including review the diagnosis, investigation and perioperative management of this condition.

Correspondence to:
Wongyingsinn M, Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.
Phone: +66-2-4197990, Fax: +66-2-4113256
E-mail: mingkwan.won@mahidol.ac.th

Case Report

A healthy 23-year-old man was injured in a motorcycle accident. He was transferred to a local hospital with a deformity of the right thigh and then referred to the tertiary hospital because of a suspicion of vascular injury. Further clinical inspection revealed a 1-cm lacerated wound in the anteromedial side of the right leg and stepping at the left patella; but the neurovascular status of both legs was still intact. The right leg was immobilized and both legs were investigated. The radiography showed fracture of the right tibial shaft, subtrochanteric fracture of the right femur and fracture of the left patella. The patient had an alcohol smell on the breath and was drowsy; but

easily wakened up and well orientated. There was no evidence of head injury. Respiratory and hemodynamic status was stable. The patient's preoperative laboratory investigations revealed: hemoglobin (Hb) 128g/L, platelet count 168x109 /L, leukocyte count (WBC) 10.4x109 /L, sodium 143 mmol/L, potassium 3.6 mmol/L, chloride 103 mmol/L, bicarbonate 27 mmol/L, prothrombin time 14.1 sec, activated partial thromboplastin time 26.3 sec, and creatinine 1 umol/L. After a diagnosis, he was urgent scheduled to have a debridement of the open right tibia fracture and apply a skeletal traction at right distal femur after 12 hours of injury.

Because of the patient's drowsiness, a spinal anesthetic was planned for the procedure in a purpose of observing level of consciousness. In the operating theater and under routine monitoring, a 25G Whitacre needle was used to administer 14 mg isobaric bupivacaine at the L3-4 interspace in right lateral position with the immobilization of the right leg; a sensory block to pinprick was generated at the T10 dermatomes. The patient's vital signs remained within physiologic ranges.

One hour after incision, the patient was suddenly agitated with tachycardia but did still follow commands. No focal neurologic deficit was observed and the Glasgow coma score was 15 (eye opening spontaneously; oriented verbal response; obeys commands). Both pupils were equal and reactive to light. His respiratory rate was 20 per minute, blood pressure was 130/68 mmHg, heart rate was 125 per minute, and oxygen saturation was 97% under 3 L per minute oxygen via nasal cannula. Neurosurgeon team was consulted to evaluate the patient intraoperatively. Duration of the operation was 85 minutes, estimated intraoperative blood loss was 100 mL and the patient received 1,400 mL of acetar solution intravenously. After completion of surgery, the patient was immediately sent to do a noncontrast cerebral computed tomogram (CT) and it showed no abnormalities (Fig. 1).

On neurologic examination 2 hours postoperatively, it was noted that the patient developed a generalized tonic-clonic seizure and progressed into a coma with the Glasgow coma score of 6 (no eye opening; no verbal response; abnormal flexion to pain). His trachea was intubated to protect the airway and petechial skin rash was noted on the anterior chest. Laboratory data including electrolytes, glucose level and toxicological screening were unremarkable. Cerebral FES was suspected and the patient was transferred to the intensive care unit for

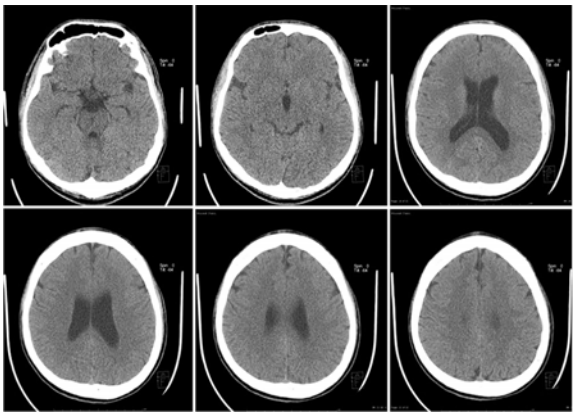

Fig. 1 Immediate non-contrast CT of the brain after the operation showing unremarkable finding.

hemodynamic and neurological monitoring. Six hours postoperatively, CT pulmonary angiogram revealed no evidence of pulmonary embolism and CT cerebral angiogram revealed generalized brain swelling and no abnormality intracranial vessels. Anticonvulsants were started.

With further deterioration in his neurological status 24 hour postoperatively, magnetic resonance imaging (MRI) of the brain was obtained (Fig. 2) which revealed multiple punctiform hyperintense lesions on T2-weighted and fluid attenuated inversion recovery (FLAIR) scattering at centrum semiovale, periventricular white matter, splenium of corpus callosum, subcortical white matter, right caudate, right thalamus, cerebral cortex of bilateral cerebral hemispheres (predominate at both high frontal and parietal regions) and both cerebellar hemispheres corresponding to multiple restricted diffusion isointense to hypointense areas on T1-weighted images. Multiple microbleed scattering at centrum semiovale, periventricular white matter, splenium of corpus callosum, gray-white junction of bilateral cerebral hemispheres (predominate at both high frontal regions), right basal ganglion and left cerebral peduncle. The differential diagnosis includes shower emboli combined with watershed infarction and diffuse axonal injury. These MRI findings were consistent and provided a confirmation of clinical suspicious of cerebral FES.

On the basis of these findings, a transesophageal echocardiography (TEE) was performed under volume support ventilation and demonstrated no evidence of a patent foramen ovale with colour Doppler and agitated saline studies, no evidence of right to left shunt and the right ventricle

was not dilated. An ophthalmologist was consulted and fundoscopy revealed retinal edema, small haemorrhages and fat globules in retinal vessels so bilateral central retinal artery occlusion (CRAO) was suspected.

By the seventh postoperative day, the subsequent postoperative course showed gradual improvement of neurological status and Glasgow coma score started to improve. A repeat MRI demonstrated an increase in size of previous areas infarction, especially bilateral frontal and parietal regions. The previous restricted diffusion areas turned to be pseudonormalization on the apparent diffusion coefficient (ADC). These findings are suggestive of subacute stage of multiple lacunar infarctions at the same locations in previous MRI (Fig. 3). Magnetic resonance perfusion showed hypoperfusion at bilateral frontal regions when compared with parietal and occipital regions. The patient had regained full consciousness within the next 7 days.

About 4 months after the injury, clinical neurologic examination was back to normal and the bilateral central retinal artery occlusion had completely resolved. The patient was transferred to the rehabilitation ward and performed physical rehabilitation. A follow-up MRI showed a transformation of previously seen multiple lacunar infarctions at bilateral frontal, parietal, periventricular region and centrum semiovale to be a nonspecific white matter change. There was focus brain atrophy at cerebral, cerebellar and brainstem area (Fig. 4). Finally, the patient was discharged from the hospital 5 months after surgery in excellent clinical condition.

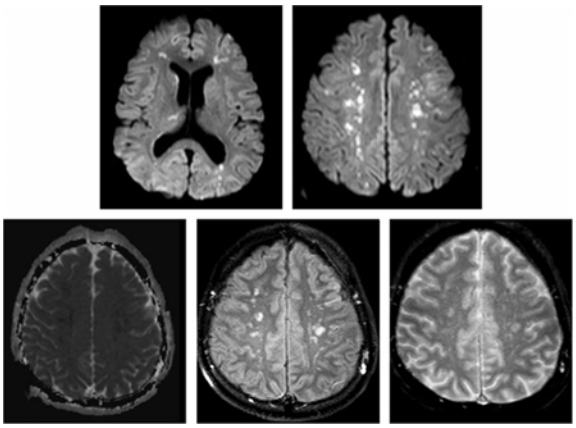

Fig. 2 MRI brain on postoperative day 1 revealed multiple punctiform hyperintense lesions on T2-weighted and fluid attenuated inversion recovery (FLAIR) scattering at centrum semiovale, periventricular white matter, splenium of corpus callosum, subcortical white matter, right caudate, right thalamus, cerebral cortex of bilateral cerebral hemispheres (predominate at both high frontal and parietal regions) and both cerebellar hemispheres corresponding to multiple restricted diffusion isointense to hypointense areas on T1-weighted images; multiple microbleed scattering at centrum semiovale, periventricular white matter, splenium of corpus callosum, gray-white junction of bilateral cerebral hemispheres (predominate at both high frontal regions), right basal ganglion and left cerebral peduncle.

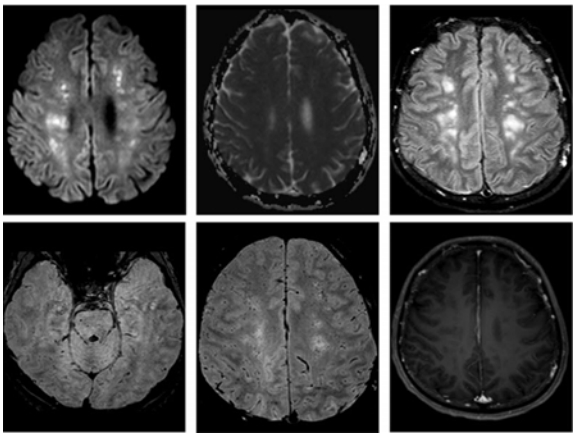

Fig. 3 MRI brain on postoperative day 7 demonstrated an increase in size of previous areas infarction, especially bilateral frontal and parietal regions. The previous restricted diffusion areas turned to be pseudonormalization on the apparent diffusion coefficient (ADC).

Discussion

FES is a serious complication which causes morbidity and mortality following long bone fracture of the lower extremities. The common surgical procedures predisposing to FES are intramedullary nailing of long bones, hip and knee arthroplasty. The incidence is estimated to be 3 to 4% and the mortality rate is 10 to 20% especially in elderly patients with multiple medical problems or decreased physiologic reserves. The pathogenesis of FES is not clearly understood but high intramedullary pressure is the main factor for fatty marrow release into the circulation.

Major and minor criteria were suggested to be used for the diagnosis of FES by Gurd et al in 1974[3]. The major criteria are based on the classic triad of respiratory insufficiency; cerebral involvement and petechial rash (Table 1). The minor criteria are based on

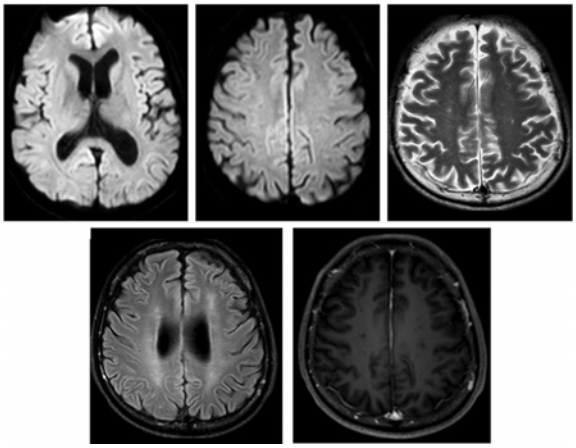

Fig. 4 MRI brain on 4 months after the operation showed a transformation of previously seen multiple lacunar infarctions at bilateral frontal, parietal, periventricular region and centrum semiovale to be a nonspecific white matter change. There was focus brain atrophy at cerebral, cerebellar and brainstem area.

clinical and laboratory features; and a positive diagnosis is made on finding at least one major criterion and four minor criteria with fat macroglobulaemia (Table 1)[2,3]. However, this diagnostic criterion has been criticized for not specifically assessing oxygenation with arterial blood gas which can be used as an early indicator of FES[5]. Lindeque et al. proposed respiratory parameters as alternative criteria for diagnosis of FES (Table 2)[5]. Schonfeld et al. proposed a semi-quantitative measure for diagnosis of FES which was seven clinical features and a cumulative score more than 5 was required for diagnosis of FES (Table 3)[6].

In this patient, the first manifestation was agitation. Radiology may be useful when patients have neurological involvement. While computer tomography (CT) scanning may show only generalised non-specific cerebral edema, magnetic resonance imaging (MRI) is more sensitive with specific abnormalities to identify cerebral FES including both hypointense areas on T1-weighted images and hyperintense regions on T2-weighted images, FLAIR sequences, characteristically located along the boundary zones of the major vascular territories[7,8]. Chest radiography: serial radiographs reveal increasing diffuse bilateral pulmonary infiltrates within 24-48 hours of onset of clinical findings. In patients who have pulmonary embolism, Helical chest CT may show lodged embolic particles in the capillary beds; or nodular or ground glass opacities in the setting of fat embolism[9]. Ventilation/perfusion scan may demonstrate a mottled pattern of subsegmental perfusion defects with a normal ventilatory pattern. Presence of fat globules in the retinal vessels is also helpful in the diagnosis of FES.

Nowadays, there is no specific treatment for FES; prevention, early diagnosis, and supportive treatment are management which can be done for this

Table 1. Gurd's criteria for the diagnosis of fat embolism syndrome[2,3]

Major criteria	Respiratory insufficiency
	Cerebral involvement
	Petechial rash
Minor criteria	Pyrexia (>39.4°C)
	Tachycardia (>120 beats.min-1)
	Retinal changes of fat or petechiae
	Jaundice
	Renal changes (anuria or oliguria)
Laboratory features	Anaemia
	Thrombocytopenia
	High erythrocyte sedimentation rate
	Fat macroglobulaemia

A positive diagnosis is made on finding at least one major feature with four minor features and fat macroglobulaemia

Table 2. Lindeque's criteria for diagnosis of fat embolism syndrome[5]

1) Sustained PaO_2 of less than 8 kPa (FiO_2 0.21)
2) Sustained $PaCO_2$ of more than 7.3 kPa or pH of less than 7.3
3) Sustained respiratory rate of greater than 35 breaths. min-1 even after adequate sedation
4) Increased work of breathing: dyspnea, accessory muscles use, tachycardia and anxiety

Table 3. Schonfeld's criteria for diagnosis of fat embolism syndrome[6]

Criteria	Score
Petechiae	5
Chest x-ray changes (diffuse alveolar infiltrates)	4
Hypoxemia (PaO_2 <9.3 kPa)	3
Fever >38°C	1
Tachycardia (pulse >120 beats min^{-1})	1
Tachypnea (respiratory rate >30 bpm)	1
Confusion	1

Cumulative score more than 5 is required for diagnosis of fat embolism syndrome

syndrome. Early stabilization of the fracture site decreases the incidence of FES. Modification of surgical technique such as apply plate or external fixation instead of intramedullary nailing significantly reduces the intramedullary hypertension and bone marrow release into the circulation which minimise the risk for developing FES. It is very important to recognise that fat embolism is an iatrogenic complication of intramedullary surgical procedures. The anesthetic technique for high risk patients of FES is still debatable due to considering between perfect oxygenation under general anaesthesia and sympathetic block under spinal block. Regional anesthesia has been reported to have lower incidences of major perioperative complications including deep vein thrombosis and pulmonary embolism compared with general anesthesia[10-13]. However, Wang et al. deduced that general anaesthesia resulted is superior in term of the mortality rates to spinal anaesthesia for patients who have a high risk of FES[14].

In addition to intraoperative standard monitoring, using of an arterial line for continuous hemodynamic and blood gas monitoring is recommended in high risk patients[1]. Intraoperative transesophageal echocardiography can be used to observe fat emboli and monitor intraoperative volume status and cardiac function[1]. Pulmonary artery pressure monitoring has also been recommended in bilateral procedures[1]. Although invasive monitoring is useful to detect fat embolism and its sequelae, there is no evidence to suggest these interventions improve outcomes in FES[4].

Supportive treatment consists of respiratory and cardiovascular stabilization. Securing the airway, oxygen therapy and continuous positive airway pressure ventilation to maintained PaO_2 higher than 90 mmHg are recommended[3]. Appropriate hydration and stabilization of hemodynamic are very important. Albumin administration may be helpful for maintaining the blood volume. While corticosteroids have been effective in preventing development of FES in several trials, particularly with high dose in the presence of cerebral edema; treatment with heparin, alcohol, dextrans and hypertonic dextrose, have not proved to be of any benefit and may be detrimental[5,6,15-17].

Conclusion

In summary, our case study was a patient who developed FES after urgent debridement and application of skeletal traction for the right femur. FES is a significant cause of mortality and morbidity in trauma patients. Three presentations of this patient were a sudden deterioration of consciousness, respiratory dysfunction and petechial. Surgeons and anesthesiologists should recognize high risk patients; and a high index of suspicion is required for early clinical diagnosis in high risk patients. Furthermore, early diagnosis and appropriate management of fat embolism are important and patients should be comprehensively monitored in the perioperative period.

What is already known from this topic?

FES is a serious complication of long bone fracture and surgery involving intramedullary manipulation. This syndrome is heterogeneous and has no pathognomonic features; there is no specific diagnostic method for FES.

What this study adds?

Diagnosis of FES relies on clinical presentation; magnetic resonance imaging can be used to confirm the diagnosis in cases with atypical manifestation. Initiation of prompt supportive care of the involved organ systems will help in reducing the morbidity and mortality.

Potential conflicts of interest

None.

References

1. Bulger EM, Smith DG, Maier RV, Jurkovich GJ. Fat embolism syndrome. A 10-year review. Arch Surg 1997; 132: 435-9.
2. Gurd AR. Fat embolism: an aid to diagnosis. J Bone Joint Surg Br 1970; 52: 732-7.
3. Gurd AR, Wilson RI. The fat embolism syndrome. J Bone Joint Surg Br 1974; 56B: 408-16.
4. Johnson MJ, Lucas GL. Fat embolism syndrome. Orthopedics 1996; 19: 41-8.
5. Lindeque BG, Schoeman HS, Dommisse GF, Boeyens MC, Vlok AL. Fat embolism and the fat embolism syndrome. A double-blind therapeutic study. J Bone Joint Surg Br 1987; 69: 128-31.
6. Schonfeld SA, Ploysongsang Y, DiLisio R, Crissman JD, Miller E, Hammerschmidt DE, et al. Fat embolism prophylaxis with corticosteroids. A prospective study in high-risk patients. Ann Intern Med 1983; 99: 438-43.
7. Satoh H, Kurisu K, Ohtani M, Arita K, Okabayashi S, Nakahara T, et al. Cerebral fat embolism studied by magnetic resonance imaging, transcranial Doppler sonography, and single photon emission

computed tomography: case report. J Trauma 1997; 43: 345-8.
8. Citerio G, Bianchini E, Beretta L. Magnetic resonance imaging of cerebral fat embolism: a case report. Intensive Care Med 1995; 21: 679-81.
9. Gallardo X, Castaner E, Mata JM, Rimola J, Branera J. Nodular pattern at lung computed tomography in fat embolism syndrome: a helpful finding. J Comput Assist Tomogr 2006; 30: 254-7.
10. Perka C, Arnold U, Buttgereit F. Influencing factors on perioperative morbidity in knee arthroplasty. Clin Orthop Relat Res 2000; 183-91.
11. Rodgers A, Walker N, Schug S, McKee A, Kehlet H, van Zundert A, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. BMJ 2000; 321: 1493.
12. Holte K, Kehlet H. Effect of postoperative epidural analgesia on surgical outcome. Minerva Anestesiol 2002; 68: 157-61.
13. Kehlet H, Holte K. Effect of postoperative analgesia on surgical outcome. Br J Anaesth 2001; 87: 62-72.
14. Wang AZ, Ma QX, Zhao HJ, Zhou QH, Jiang W, Sun JZ. A comparative study of the mortality rate of rats receiving a half lethal dose of fat intravenously: under general anaesthesia versus under spinal anaesthesia. Injury 2012; 43: 311-4.
15. Shier MR, Wilson RF, James RE, Riddle J, Mammen EF, Pedersen HE. Fat embolism prophylaxis: a study of four treatment modalities. J Trauma 1977; 17: 621-9.
16. Stoltenberg JJ, Gustilo RB. The use of methylprednisolone and hypertonic glucose in the prophylaxis of fat embolism syndrome. Clin Orthop Relat Res 1979; 211-21.
17. Enneking FK. Cardiac arrest during total knee replacement using a long-stem prosthesis. J Clin Anesth 1995; 7: 253-63.

รายงานผู้ป่วย: กลุ่มอาการลิ่มไขมันอุดหลอดเลือดสมองหลังจากการผ่าตัดกระดูกต้นขาหักและดึงน้ำหนักถ่วงผ่านกระดูก

มิ่งขวัญ วงษ์ยิ่งสิน, ดิเรก ตันติเกตุ, ธีรพล วิทธิเวช, อรสา ชวาลภาฤทธิ์

ภูมิหลัง: *อุบัติการณ์ของกลุ่มอาการลิ่มไขมันอุดหลอดเลือดสามารถพบได้ร้อยละ 3 ถึง 4 ของผู้ป่วยที่ได้รับอุบัติเหตุ โดยเฉพาะผู้ป่วยที่มีกระดูกขนาดใหญ่หักร่วมด้วย*

วัตถุประสงค์: *เพื่อนำเสนอผู้ป่วยที่มีกลุ่มอาการลิ่มไขมันอุดหลอดเลือดหลังจากการผ่าตัดกระดูกต้นขาหักและดึงน้ำหนักถ่วงผ่านกระดูก การทบทวนวรรณกรรม การวินิจฉัย การตรวจเพิ่มเติม และการดูแลรักษาผู้ป่วย*

รายงานผู้ป่วย: *ผู้ป่วยชายไทยอายุ 23 ปีได้รับบาดเจ็บจากอุบัติเหตุและเข้ารับการผ่าตัดกระดูกต้นขาหักและดึงน้ำหนักถ่วงผ่านกระดูก ขณะผ่าตัดผู้ป่วยเริ่มมีอาการกระสับกระส่าย ชัก และระดับความรู้สึกตัวลดลง ผลการตรวจภาพแม่เหล็กไฟฟ้าสมองเข้าได้กับกลุ่มอาการลิ่มไขมันอุดหลอดเลือดสมอง ผู้ป่วยใช้เวลาในการพักฟื้นนาน 4 เดือนจึงกลับสู่สภาวะปกติ*

สรุป: *กลุ่มอาการไขมันอุดตันเส้นเลือดเป็นภาวะแทรกซ้อนที่สำคัญของกระดูกหัก สามารถวินิจฉัยได้จากความผิดปกติ ของระบบหายใจ ระบบประสาท และจุดเลือดออกตามร่างกาย การตรวจภาพแม่เหล็กไฟฟ้าสมองสามารถใช้ เพื่อยืนยันการวินิจฉัยได้ การรักษากลุ่มอาการลิ่มไขมันอุดหลอดเลือดที่เหมาะสมคือการรักษาแบบประคับประคอง*