

Chest Radiographic Evolution in Fat Embolism Syndrome

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Objective: To characterize the temporal chest radiographic findings of fat embolism syndrome.

Material and Method: Twenty-nine patients with clinically diagnosed fat embolism syndrome between 1988-1999 were retrospectively identified from the Trauma Registry of Harborview Medical Center, University of Washington. In twenty-two patients, complete medical records and serial chest radiographs were available. All images were reviewed by a dedicated thoracic radiologist.

Results: Two of 22 patients had normal radiographs throughout hospitalization, while 20/22 developed abnormal chest radiographs. The radiographic findings were consistent with non-specific diffuse pulmonary edema in all abnormal cases. The time to appearance of evident radiographic lung injury was < 24 hours of initial trauma in 10/20 (50%), between 24-48 hours in 4/20 (20%), between 48-72 hours in 5/20 (25%), and 1 patient (1/20, 5%) developed an abnormal chest radiograph after 72 hours. Ten of 20 patients (50%) with abnormal radiographs had complete resolution of the edema pattern within 1 week of development of opacities, 3/20 (15%) cases showed complete radiographic resolution between 1- 2 weeks, 2/20(10%) cases showed complete radiographic resolution between 2-3 weeks, 1/20 (5%) showed complete radiographic resolution between 3-4 weeks, and 4/20 (20%) died without resolution of the radiographic finding.

Conclusion: The chest radiographic appearance of fat embolism syndrome is non-specific. Normal radiographs can also be seen. Most patients presenting with a normal initial radiograph develop radiographic evident abnormalities within 72 hours of injury and most cases showed radiographic resolution within 2 weeks of hospitalization. Although chest imaging play a little role in the clinical management of fat embolism syndrome, understanding of temporal presentation and evolution of the otherwise non-specific pulmonary opacities may help to avoid unnecessary evaluation in selected patients.

Keywords: Fat embolism syndrome, Chest radiograph, Pulmonary edema

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Fat embolism syndrome is an uncommon disorder typically occurring 12-72 hours after trauma⁽¹⁾. Other non-traumatic conditions that can also cause fat embolism syndrome, are quite rare, including hemoglobinopathy, diabetes, pancreatitis, severe infection, neoplasm, osteomyelitis, blood transfusion, cardiopulmonary bypass, altitude decompression, and renal transplantation^(2,3). The fat embolism syndrome is

characterized by cerebral, cutaneous and pulmonary manifestations. Neurologic abnormalities such as altered mental status are the most pronounced in this disease, occurring in up to 85% of patients compared with other organ systems, and may be the first indication of fat embolism⁽⁴⁾. Cutaneous features of fat embolism syndrome include petechiae of the skin and mucous membranes. Pulmonary manifestation are non-specific as well and include dyspnea, tachypnea, hyperpnea, and hemoptysis. The diagnosis of fat embolism syndrome is based upon the patient's history, and is supported by clinical signs of progressive

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respiratory insufficiency, thrombocytopenia, and deteriorating mental status and confirmed by the demonstration of arterial hypoxia in the absence of other disorders⁽²⁾. Pulmonary dysfunction secondary to non-cardiogenic pulmonary edema is often the most serious and life threatening aspect of fat embolism syndrome. The authors primarily sought to characterize the temporal chest radiographic features in a consecutive series of trauma patients with the diagnosis of fat embolism syndrome.

Material and Method

Twenty-nine patients clinically diagnosed with fat embolism syndrome were retrospectively identified from the Trauma Registry of Harborview Medical Center, University of Washington during the 11 year period 1988-1999. With the approval of the human subjects committee, the authors reviewed the identified patients' medical records and all inpatient chest radiographs. Data collected included demographics (age, sex, and mechanism of injury), Injury Severity Score (ISS)⁽⁵⁾, and fracture pattern. Of the initial group of 29 patients, 22 patients had complete medical records including chest radiographs for review, and comprised the study group.

Diagnostic criteria for fat embolism syndrome were based on Gurd⁽⁶⁾ which included 3 major signs: hypoxemia ($\text{PaO}_2 < 60 \text{ mmHg}$ and $\text{FiO}_2 > 0.4$), central nervous system depression, and petechiae; and six minor signs: tachycardia (heart rate > 120 beats per minute), pyrexia (body temperature $> 39^\circ\text{C}$), thrombocytopenia (platelet count $< 150 \times 10^9/\text{L}$), fat globules in the urine or sputum, retinal emboli, and unexplained fall in hematocrit. The clinical diagnosis of fat embolism syndrome required patients to have at least one major and three minor signs or two major and two minor signs.

All chest radiographs during hospital admission were reviewed and evaluated qualitatively by a dedicated thoracic radiologist aware of the clinical diagnosis, primarily for the presence or absence of pulmonary edema (diffuse increase in lung opacity), as well as interval changes in pulmonary edema. Any associated focal injury and routine clinical management of life support devices were not recorded.

Results

There were 43,022 trauma admissions between January 1988-December 1999 in our hospital. Only 29 of these patients were diagnosed with fat embolism syndrome following Gurd's criteria. Seven cases were

excluded from the present study for lack of a complete medical records or serial follow up chest radiographs. Among this group, 3 were male and 4 were female with an age range between 19-48 year-old (mean 32.3). In this excluded group the mean ISS was 16.9 (range 8-34), similar to the study group.

In the study group, 17 were men, (age ranging between 22 and 70 years (mean 44.8)) and 5 were women (age ranging between 23 and 62 years (mean 37)). The mean ISS was 15.8 (range 4-38). The average serial films per patient were 7 (range between 2-30 films). All were victims of blunt trauma, including 13 motor vehicle crashes, and 9 falls from a height. Bone fracture patterns were as follows: 14/22 (64%) had long bone fractures, 5/22 (23%) had non-long fractures (3 pelvic ring fractures and 2 spinal fractures) and 3/22 (14%) had combined fractures. There were a total of 23 long bone fractures in 22 patients, more than half 18/23 (78%) were located in the lower extremities (11 femurs, 7 tibia fibulars). Twenty-two percent were in the upper extremities (2 humeruses and 3 forearms). As to fracture status, 16/22 (73%) had closed fractures alone, 3/22 (14%) had open fractures only, and 3/22 (14%) had both open and closed fractures. Only one patient (1/22, 5%) was treated by closed reduction, whereas the remainder (21/22, 95%) had open reduction repair.

For the radiographic findings, the authors divided the patient groups into 2 major groups: those with normal chest radiographs throughout their hospital course and those who developed abnormal chest radiographs. There were two patients (2/22, 9%) with normal serial chest radiographs throughout hospitalization. Of the 20 patients (20/22) that had abnormal chest radiographs, 13/20 (65%) showed normal chest radiographs at presentation, only developing abnormalities after admission, while 7/20 (35%) had an abnormal chest radiograph at first presentation. For these 20 patients with abnormal radiographs, the findings were perihilar or diffuse pulmonary parenchyma opacities, typically of a non-specific pulmonary edema, in all cases.

The time interval between the normal presenting chest radiograph and subsequent radiographic abnormalities was < 24 hours of initial trauma in 3/13 (23%), between 24-48 hours in 4/13 (31%), between 48-72 hours in 5/13 (38%), and 1 patient (8%) developed an abnormal chest radiograph after 72 hours. The mean ISS in each of these subgroups were 15.6, 15.4, 11, and 15.8 respectively. There was no significant relationship between ISS and the time to development of chest radiographic abnormality.

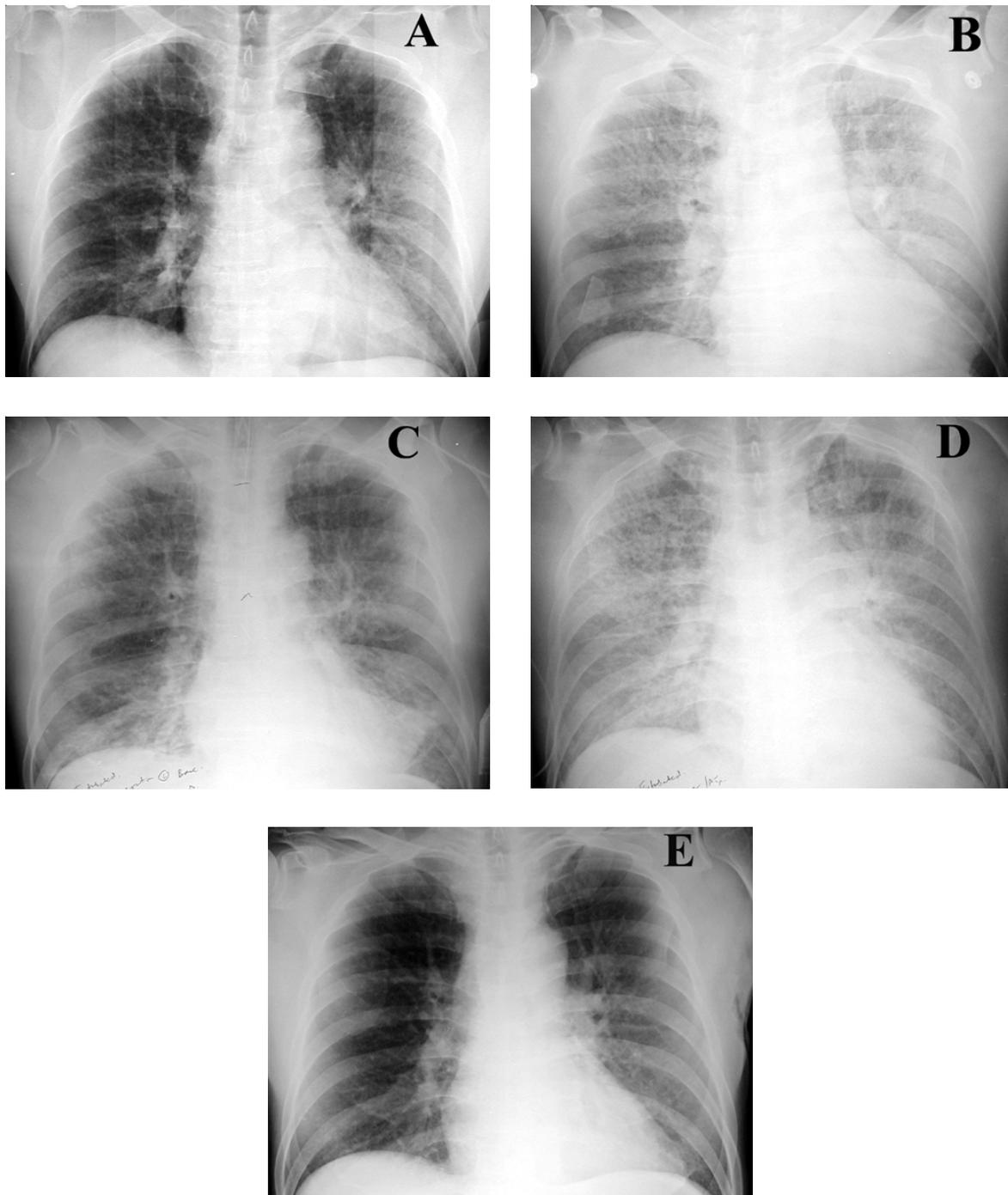


Fig. 1 Serial supine chest radiographs of a 59 year-old man with closed fracture of the right femur after falling from a roof. Fat embolism syndrome developed 24 hours after admission. Images **A-E** represent the serial films on Day 0, Day 1, Day 3, Day 4 and Day 15, respectively. This sequence shows the progression of the pulmonary opacity, which is a non-specific finding. On Day 0 (**A**), the only abnormality detected is perihilar opacity, which progresses to diffuse involvement of both lungs, worst on Day 4 (**D**). After supported treatment, the lung opacities resolved and the lung parenchyma appeared to be normal by Day 15 (**E**)

The authors also found that 10/20 (50%) showed complete radiographic resolution of the abnormal CXR within 1 week of development of lung opacities, 3/20 (15%) showed complete radiographic resolution between 1-2 weeks, 2/20 (10%) showed complete radiographic resolution between 2-3 weeks (Fig. 1), 1/20(5%) showed complete radiographic resolution between 3-4 weeks and 4/20 (20%) died before the radiographic finding was resolved. These 4 patients died on day1, day4, day25 and day30 respectively after admission (Fig. 2). The mean ISS of this subgroup are 13.2, 9.3, 15.5, 9, and 29 respectively. There was no statistically significant correlation between ISS and chest radiographic abnormality, although patients with an abnormal chest radiograph at initial presentation tended to have higher ISS.

Discussion

Fat embolism syndrome is an uncommon disorder characterized by pulmonary, cerebral and cutaneous manifestations, that has been reported to occur in 0.5-3% of patients with single long-bone fractures and in nearly 30% of patients with multiple long bone fractures^(2,7-10).

The pathophysiology of the pulmonary component of fat embolism syndrome is not completely understood, but it seems to be supported by two theories, mechanical theory and a biochemically mediated theory⁽¹¹⁾. The mechanical theory postulates that the fat globules themselves enter the venous system and obstruct the vascular bed. This effect is enhanced by aggregates of platelets and red blood cells. This theory is supported by the histologic identification of fat in

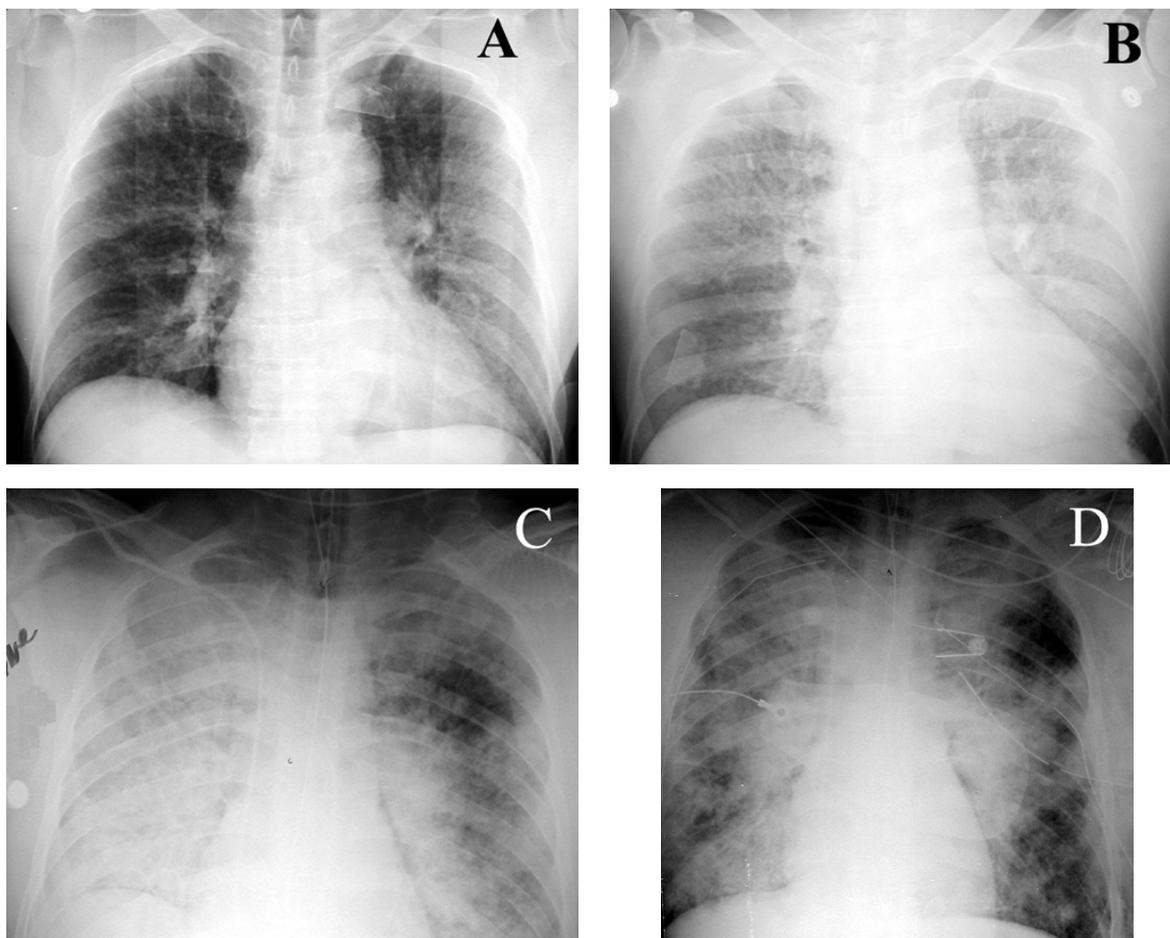


Fig. 2 The serial supine chest radiographs of a 29 year-old man with bilateral femur fractures who suffered a motor vehicle crash shows progressive diffuse pulmonary opacification from Day1 to Day4, as shown in **A** to **D**, respectively. This patient died before the time of radiograph resolution. With the proper clinical setting and time course, the diagnosis of fat embolism syndrome was made

small pulmonary vessels and the observation of elevated pulmonary arterial pressure after fat embolization in animal experiments⁽¹²⁻¹⁴⁾. Unlike other embolic events, the vascular occlusion in fat embolism is often temporary or incomplete since fat globules do not completely obstruct capillary blood flow because of their fluidity and deformability. The biochemically mediated theory for development of fat embolism syndrome proposes that the fat is transported to the lungs in the form of neutral triglycerides. They are converted by endothelial lipases into free fatty acids, which have a direct toxicity to pneumocytes and capillary endothelium. These events cause interstitial hemorrhage, diffuse alveolar damage, and chemical alveolitis^(1,2,4). The non-traumatic etiologies of fat embolism syndrome support this latter theory.

The pathologic findings of fat embolism consist of fat globules within the microvasculature, edema, alveolar hemorrhage, and pneumonitis⁽¹¹⁾, all of which are compatible with the radiographic findings found in this condition.

Chest radiographic findings can vary from normal, as found in 9% of patients in the present study, to the diffuse edema pattern typical of patients with acute respiratory distress syndrome. The radiographic findings in the present patients with fat embolism syndrome were similar to those reported previously, showing bilateral homogenous and heterogenous opacity that resemble those of pulmonary edema or acute respiratory distress syndrome⁽⁴⁾. Further, the pulmonary opacities in fat embolism syndrome typically do not clear after diuresis⁽¹⁵⁾. Specific distribution of the pulmonary opacities, not recorded in our study, can be predominantly in the perihilar area⁽¹⁶⁾, or peripheral lung zone⁽¹⁷⁾. Also upper versus lower lobe involvement differs among study groups. Berrigan TJJ, et al⁽¹⁷⁾ and Maruyama Y, et al⁽¹⁶⁾ reported a lower lobe to be the predominately involved by conventional radiographs, while an upper lobe distribution predominated in the study by Hiroaki et al⁽¹⁸⁾ and Choi et al⁽¹¹⁾.

In the present study, 19/20 (95%) patients with an abnormal CXR, developed the radiographic abnormalities within 72 hours, supporting a previous study by Feldman et al⁽⁴⁾. Although chest radiographic abnormalities typically appear 1-2 days after injury, the authors found that 7/22 (32%) had an abnormal chest radiograph on the first admission day. Two of these patients were transferred from other hospitals where the original radiographs could not be evaluated. While these patients fulfilled Gurd's criteria for fat embolism syndrome, the other 5 patients could have had other

underlying conditions that also caused diffuse pulmonary opacities for example pulmonary edema from other causes. Unfortunately, the authors do not have a pathology data to prove this.

Feldman et al noted that the resolution period of CXR abnormalities in fat embolism syndrome is typically 7-10 days⁽⁴⁾, which correlated with the present findings in which over 65% of cases showed radiographic clearing within 2 weeks of injury.

Even the temporal sequence of radiographic abnormalities in fat embolism syndrome are non-specific and can be found in other conditions in which trauma plays a part, such as pulmonary contusion, gastric content aspiration, neurogenic and other causes of pulmonary edema. The latency period for the radiographic and clinical development of fat embolism syndrome has diagnostic importance. The radiographic lung opacities found in patients with pulmonary contusions appear much earlier in the hospital course and typically clear faster than opacities seen with pulmonary fat embolism syndrome. Additionally, pulmonary contusions tend to occur focally and peripherally, seldom affected both lungs diffusely and symmetrically. Aspiration of gastric contents typically can occur at any time and have a perihilar or bibasilar distribution depending on severity and any resulting pneumonia. In virtually all patients with pulmonary contusions, radiographic abnormalities are seen within 12-24 hours of injury and begin to clear radiographically in 2 to 3 days, and usually resolve within 4 to 5 days⁽¹⁹⁾.

Even the CT scan of the chest which is not included in the present study, provided some more information about the distribution compared with chest radiographs and also suggested a unique pathophysiology of this syndrome⁽¹⁸⁾.

There are several limitations of the present study. Firstly, the authors had a relatively small patient population. Also, the chest radiographic features in patients with fat embolism syndrome are very non-specific, and are commonly seen in multi-traumatized patients without the clinical diagnosis of fat embolism syndrome. Although all of the presented patients had the clinical diagnosis of fat embolism syndrome, the authors could not be certain of the etiology or etiologies of the lung parenchymal findings in the reported cases since no pathological diagnosis was obtained. Also, frequent or daily radiographs were not obtained in all of the presented patients, so precise timing of abnormalities could not always be determined.

Fat embolism syndrome remains a clinical diagnosis of exclusion, based solely upon clinical

criteria⁽²⁰⁾. Radiographic appearances are non-specific and typical for any pulmonary edema pattern, although fat embolism syndrome can also occur with normal radiographs. Most patients presenting with a normal initial CXR developed abnormal CXR within 72 hours after admission and most cases showed resolution of lung parenchymal abnormalities within 2 weeks of hospitalization. Although chest imaging plays little role in management, recognition of the temporal sequence of radiographic abnormalities can be a clue in distinguishing pulmonary fat embolism syndrome from other pulmonary conditions

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ลักษณะผิดปกติบนภาพถ่ายรังสีทรวงอกในภาวะ Fat embolism syndrome

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วัตถุประสงค์: เพื่อหาลักษณะผิดปกติบนภาพถ่ายรังสีทรวงอกที่เฉพาะเจาะจงสำหรับผู้ป่วย Fat embolism syndrome
วัสดุและวิธีการ: การศึกษานี้เป็นการเก็บตัวอย่างย้อนหลังในช่วงปี พ.ศ. 2531-2542 ในผู้ป่วยของโรงพยาบาล Harborview Medical Center, มลรัฐ Washington โดยศึกษาจากจำนวนผู้ป่วยที่มีอาการแสดงของ Fat embolism syndrome ทั้งหมด 29 ราย ซึ่งมีเพียง 22 รายที่มีบันทึกประวัติผู้ป่วยรวมทั้งผลการตรวจภาพถ่ายรังสีทรวงอกครบ ภาพถ่ายรังสีทรวงอกทั้งหมดได้รับการอ่านโดยรังสีแพทย์ผู้เชี่ยวชาญทางระบบทรวงอก

ผลการศึกษา: จำนวนผู้ป่วย 2 ใน 22 รายมีผลภาพถ่ายรังสีทรวงอกปกติในขณะที่ 20 รายที่เหลือพบความผิดปกติบนภาพถ่ายรังสีทรวงอก ซึ่งในจำนวนนี้ภาพถ่ายรังสีทรวงอกแสดงถึงลักษณะของ pulmonary edema ซึ่ง สามารถพบในโรคอื่น ๆ ได้เช่นกัน ผู้ป่วยจำนวน 10 ราย (50%) พบความผิดปกติบนภาพถ่ายรังสีทรวงอกภายในระยะเวลา น้อยกว่า 24 ชั่วโมง หลังเกิดการบาดเจ็บ, 4 ราย (20%) พบความผิดปกติในช่วง 24-48 ชั่วโมงหลังเกิดการ บาดเจ็บ, 5 ราย (25%) พบความผิดปกติในช่วง 48-72 ชั่วโมงหลังเกิดการบาดเจ็บ และ มีเพียง 1 ราย (5%) ที่พบความผิดปกติ ช่วงหลังจาก 72 ชั่วโมงหลังเกิดการบาดเจ็บ ในกลุ่มผู้ป่วยที่พบความผิดปกติในภาพถ่ายรังสีทรวงอกพบว่า ภาพถ่ายรังสีทรวงอกกลับมาปกติภายใน 1 สัปดาห์จำนวน 10 ราย (50%) ภายใน 1-2 สัปดาห์ 1 ราย (5%) และ จำนวน 4 ราย (20%) เสียชีวิตก่อนภาพถ่ายรังสีทรวงอกจะกลับมาเป็นปกติ

สรุป: ลักษณะความผิดปกติทางภาพถ่ายรังสีทรวงอกในภาวะ Fat embolism syndrome นั้นไม่เฉพาะเจาะจงสำหรับ โรคนี้ และมีลักษณะเหมือนภาพถ่ายรังสีทรวงอกปกติที่พบในภาวะ Pulmonary edema ผู้ป่วยส่วนใหญ่มีภาพถ่ายรังสี ทรวงอกที่ปกติในตอนแรก และพัฒนาจนเกิดความผิดปกติภายใน 72 ชั่วโมงหลังเกิดการบาดเจ็บ และหายเป็นปกติ ภายใน 2 สัปดาห์หลังเข้ารับการรักษาภายในโรงพยาบาล แม้ภาพถ่ายรังสีทรวงอกจะมีความสำคัญทางคลินิก ไม่มากนักแต่การที่ทราบถึงลักษณะการเปลี่ยนแปลงที่เกิดขึ้นดังกล่าวจะช่วยลดปริมาณการส่งวินิจฉัยเพิ่มเติม ที่ไม่จำเป็นในผู้ป่วยบางราย