Pulmonary Hemorrhage During Computed Tomography–Guided Percutaneous Lung Biopsy: A Case Report and Review of the Literature

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Percutaneous lung biopsy represents a minimally invasive method of obtaining lung tissue to aid in the diagnosis of various pulmonary diseases. Although the technique has major advantages, including being less invasive and having a more rapid recovery than open thoracotomy, complications such as bleeding may occur. To date, there is limited information regarding the complications and their treatment associated with this procedure. We describe a 22-year-old man with chronic granulomatous disease who experienced a pulmonary hemorrhage after percutaneous lung biopsy using computed tomography guidance while he was under general endotracheal anesthesia. Potential treatment algorithms and strategies are presented.

Keywords: Biopsy, lung biopsy, open thoracotomy, treatment algorithms.

In patients presenting with parenchymal or interstitial lung disease, it may be mandatory to obtain a tissue specimen to arrive at an accurate diagnosis. Depending on the clinical scenario, including the amount of tissue required, both open and noninvasive techniques may be feasible. Percutaneous lung biopsy (PBL) represents a minimally invasive method of obtaining lung tissue. Although it is less invasive and the recovery is more rapid than open procedures, complications such as bleeding may occur. We present the case of a 22-year-old man with chronic granulomatous disease in whom a pulmonary hemorrhage developed after left-sided PBL using computed tomography (CT) guidance while he was under general endotracheal anesthesia. Potential treatment algorithms and strategies are presented.

Case Summary
A 22-year-old, 49-kg man with chronic granulomatous disease had been treated at our facility, Nationwide Children’s Hospital in Columbus, Ohio, since childhood. The patient was admitted because of an increase in size, on a recent CT scan, of a preexisting right upper lobe pulmonary lesion. He was known to be noncompliant as an outpatient with his prescribed antifungal therapy of voriconazole and amphotericin B. Institutional review board approval is not required at Nationwide Children’s Hospital for the presentation of single case reports.

His medical history included necrotizing mediastinal lymphadenitis, extended-spectrum β-lactamase infection, and liver abscesses due to methicillin-resistant Staphylococcus aureus. Following admission, antifungal therapy with terbinafine was started in addition to the voriconazole and amphotericin B. He experienced fever 10 days after admission, with associated headache, prompting the initiation of antibiotic therapy with piperacillin-tazobactam (Zosyn) and vancomycin. Because of the onset of headache, magnetic resonance images of the brain were obtained but showed no central nervous system involvement. After blood cultures were found to be negative, the vancomycin and piperacillin-tazobactam regimens were discontinued. Another chest CT scan 12 days after admission demonstrated that there had been no change in the size of the right upper lobe lesion; however, there were 2 new nodular lesions in the left lower lobe that had not been previously noted. As his fever continued, there were concerns for progression of the known fungal infection or potential for other fungal pneumonia or secondary bacterial infection with extended-spectrum β-lactamase gram-negative rods. The decision was made for the patient to undergo a CT-guided PBL of one of the new left-sided lesions to obtain a differential for treatment.

Additional medical history included prior acute kidney injury, kidney stones, aortic root dilation, aortic valve regurgitation, dematiaceous fungi infection, anemia, and depression. His surgical history included liver biopsy, a right upper and partial right middle lung lobectomy, biopsy of a submandibular node, and insertion of an implanted central venous port. Medications included amphotericin B, voriconazole, trimethoprim-sulfamethox-
Hg), oxygen saturation of 100% with an in-rate of 56/min (sinus bradycardia), NIBP of 109/55 mm

capnography. Postinduction vital signs showed a heart rate of 110/min, NIBP was 156/80 mm Hg, and an oxygen saturation measured by pulse oximetry

Results of the preoperative physical examination showed a young, cachectic man in no acute distress, breathing room air, with evidence of oral and dermatologic fungal infection. Breath sounds were clear and equal bilaterally. Airway examination revealed a Mallampati class 2 assessment and a thyromental distance greater than 3 fingerbreadths with normal head and neck range of motion. Two months earlier, during the patient’s anesthetic for insertion of an implanted central venous port, he had beenatraumatically intubated with a 7.0-mm endotracheal tube using a Macintosh No. 3 blade, and a grade 1 view was obtained.

Preoperative laboratory evaluation included a complete blood cell count, hemoglobin level of 7.4 g/dL, and hematocrit of 23.3%. The platelet count was normal. The prothrombin time was slightly elevated at 16 seconds with an international normalized ratio of 1.24; the activated partial prothrombin time and fibrinogen levels were normal. The patient did not have a current blood typing and crossmatching.

The patient was given nothing by mouth for 8 hours. He had an existing peripherally inserted central venous catheter in the right arm. He was transported into the CT scanner room, and electrocardiogram, noninvasive blood pressure (NIBP), and oxygen saturation monitors were placed. Preinduction vital signs showed a heart rate of 63/min with a normal sinus rhythm, NIBP reading of 140/86 mm Hg (mean arterial pressure [MAP] of 99 mm Hg), and an oxygen saturation of 100% on room air. No preoperative anxiolytics or antibiotics were required. After preoxygenation with 100% inspired oxygen, anesthesia was induced with 200 mg of propofol and 100 µg of fentanyl. Endotracheal intubation was facilitated by administration of 20 mg of rocuronium, and the airway was secured with a 7.0-mm cuffed endotracheal tube, with equal, bilateral breath sounds and normal results of capnography. Postinduction vital signs showed a heart rate of 56/min (sinus bradycardia), NIBP of 109/55 mm Hg (68 mm Hg), oxygen saturation of 100% with an inspired oxygen concentration (FiO₂) of 50%, and an end-tidal carbon dioxide (ETCO₂) concentration of 36 mm Hg. Anesthesia was maintained with isoflurane (exhaled concentration, 1%-1.2%). Mechanical ventilation was provided at a rate of 12/min, a positive inspiratory pressure of 12 to 16 cm H₂O to deliver a tidal volume of 10 mL/kg, and a positive end-expiratory pressure (PEEP) of 5 cm H₂O. After the airway was secured, the patient was positioned prone on the scanner bed with direct access to the airway. The patient's blood pressure decreased in the prone position, with a decline of the MAP to the 40 to 50 mm Hg range. Blood pressure was supported with incremental doses of ephedrine, 5 to 10 mg at a time, to maintain the MAP at or above 60 mm Hg. A total of 25 mg of ephedrine had been given with additional crystalloid, all before commencement of the procedure by the interventional radiologist.

After sterile preparation and draping, the procedure began, with the interventional radiologist obtaining a view using real-time CT guidance. The lesion for biopsy was identified in the left aspect of the chest, and the specimen was obtained with a single deep pass of an 18-gauge needle through a superficially placed 17-gauge coaxial needle. The interventional radiologist stated that a left-sided hematoma was noted on the CT images and that he was placing an absorbable gelatin sponge (Gelfoam, Pfizer) into the biopsy site. Several moments later, there was complete loss of ETCO₂, major reduction in lung compliance, and difficulty with manual ventilation. The patient was ventilated, with an FiO₂ of 100%, and removed from the CT scanner. At the time, the heart rate was 64/min, NIBP was 92/43 mm Hg (52 mm Hg), and oxygen saturation measured by pulse oximetry (SpO₂) was 100% with FiO₂ of 100%. As the drapes were removed, a large amount of blood was noted in both the patient's endotracheal tube and the anesthesia circuit. Subsequent NIBP was 100/41 mm Hg (53 mm Hg), and the SpO₂ was 100%. The endotracheal tube was suctioned, without return of ETCO₂, when the patient was manually ventilated. The patient was placed in the supine position on the hospital bed in anticipation that cardiac arrest could occur.

Because the ETCO₂ remained undetectable and the source of hemorrhage was known to be in the left lung, the right lung was isolated by advancement of the endotracheal tube into the right mainstem bronchus. This maneuver resulted in the return of the ETCO₂ waveform. The heart rate was 110/min, NIBP was 156/80 mm Hg (94 mm Hg), and SpO₂ was 100% with 100% FiO₂. It had been established that ventilation could be achieved through right lung isolation, and all vital signs remained stable. Therefore, the decision was made to withdraw the endotracheal tube to a level above the carina and apply a higher level of PEEP in an attempt to tamponade the bleeding, with the knowledge that the endotracheal
tube could easily be re avanzed to isolate and ventilate through the right lung should the maneuver fail. The endotracheal tube was withdrawn several centimeters, and a PEEP of 10 cm H$_2$O was initiated. Adequate ventilation with bilateral breath sounds and positive ETCO$_2$ of 44 mm Hg were established. The patient was assessed and monitored for 10 to 15 minutes. During that time, the vital signs remained stable, and the NIBP ranged from 110 to 140/50 to 60 mm Hg with a MAP of 60 to 70 mm Hg without the need for pharmacologic intervention. The heart rate was 70 to 90/min, and the SpO$_2$ was 97% to 100% on an FiO$_2$ of 100%. There was no further bleeding in the endotracheal tube.

The patient’s trachea was left intubated, 4 mg of midazolam and 20 mg of rocuronium was administered, and he was transported to the pediatric intensive care unit (PICU). Pulmonary hygiene, including chest physiotherapy, lavage, and mechanical ventilatory support via endotracheal tube, was continued in the PICU. Initial ventilator settings included an FiO$_2$ of 40%, rate of 16/min, peak inflating pressure of 28 cm H$_2$O, PEEP of 10 cm H$_2$O, and pressure support of 10 cm H$_2$O. These settings maintained oxygen saturations at 99% to 100%. Several hours after admission to the PICU, the patient had a coughing spell that resulted in more frank hemoptysis; however, no intervention other than lavage and suctioning of the endotracheal tube was required.

Less than 24 hours later, the ventilator settings were weaned to continuous positive airway pressure of 10 cm H$_2$O with pressure support of 6 cm H$_2$O and 30% FiO$_2$. He continued to have episodes of coughing and frank, bright red hemoptysis as well as a fever (temperature of 38.3°C). Because of ongoing coughing and bleeding, pharmacologic paralysis was started along with continuous sedation with midazolam and fentanyl infusions. There was discussion between the interventional radiology team and the PICU team to schedule the patient for an angiogram with potential pulmonary embolization if the patient were to continue having episodes of frank hemoptysis. His hemoglobin level drifted down to 6.5 g/dL. One unit of packed red blood cells was transfused.

Forty-eight hours after the initial episode, his hemoglobin level stabilized in the 7 to 8 g/dL range. Results of repeated coagulation function profiles remained normal. After sedation and pharmacologic paralysis was discontinued, he continued to have episodes of hemoptysis; the blood was darker and clots were noted, but with no decline in the hemoglobin concentration. A chest radiograph revealed increasing left basilar airspace opacity and increased streaky opacity in the right upper lobe and right lung apex. There was a gradual wean of the ventilatory support and 4 days after admission to the PICU, his trachea was extubated, and he was given 50% oxygen via face mask. Because of a decreased level of consciousness and hypercarbia, noninvasive ventilation was initiated. When sedation was further decreased and the patient became more alert, his spontaneous ventilatory effort improved, and he was transitioned back to oxygen administered via face mask. Over the next 24 hours, the oxygen was decreased to room air.

The patient was discharged to the stepdown unit 6 days after the initial incident. He remained on the stepdown unit for an additional week while antibiotic and antifungal therapy was completed. He was then discharged to home.

**Discussion**

Compared with open biopsy, the percutaneous approach may be advantageous because it is less invasive, thereby decreasing procedure and recovery times, with less morbidity. Open techniques may result in pneumothorax, prolonged air leak, and bleeding, requiring thoracostomy drainage. The use of CT guidance allows for precision in localizing the lesion and increases the proportion of true-positive biopsies. Although pulmonary hemorrhage is a recognized complication of PLB, it is typically self-limited, confined to the lung parenchyma or localized to the needle track. However, as demonstrated by the clinical course in our patient, hemorrhage is always a potential complication even when CT guidance is used.

Given its predilection for the pediatric population, most of the literature about chronic granulomatous disease and its clinical manifestations including lung abscesses is from the pediatric population. As is common at many tertiary care pediatric institutions, patients affected with these disorders present during childhood and may continue their care at a children’s hospital despite their “adult” age.

There are limited data regarding the incidence of complications arising from CT-guided PLB in the literature. The most commonly described complications are pneumothorax, hemorrhage/hemoptysis, pleural effusion, pulmonary contusion, air embolism, and empyema, with pneumothorax and pulmonary hemorrhage being the most common. The incidence of moderate or severe complications has been as high as 43% in some reports, with some complications being life-threatening. A small lesion size and greater lesion depth are associated with a higher risk of bleeding due to a long biopsy path. Given our experience with this patient, we would recommend that a blood typing and crossmatching be obtained before the procedure, with the assurance that blood is available. Additionally, as deterioration during the procedure may occur, we recommend that the availability of an ICU bed should be verified before the procedure.

Patient-related factors that contribute to complications with CT-guided PLB include altered coagulation function, ASA status 3 or higher, suspected pulmonary fungal infection, immunocompromised status, compromised pulmonary function, or a lesion located near a large vessel or vital organ. As was present in our
patient, fungal lesions have a tendency to bleed spontaneously or following biopsy. Fungi may produce toxins that can induce inflammatory cytokines, leading to acute cell injury and death, causing local destruction of the alveolar capillary wall, and thereby predisposing to pulmonary hemorrhage. Transmural pressures insufficient to rupture normal capillaries may be pathogenic under these conditions. In the chronic phase, fungal granulomatous disease can cause extravascular inflammation as well as vasculitis of small to medium-sized vessels of the upper and lower respiratory tract, resulting in a bleeding tendency and the potential for hemorrhage during biopsy.

Given the potential for bleeding during such procedures, appropriate preparation is necessary to ensure successful resuscitation should pulmonary hemorrhage occur. This preparation includes preoperative evaluation and optimization of coagulation function and platelet count, placement of adequate vascular access, and the availability of blood in the event of severe hemorrhage. Because substantial intraparenchymal or airway bleeding, as occurred in our patient, may impede respiratory function, endotracheal intubation is suggested. When the respiratory status and hemodynamic status are stable, conservative maneuvers to stop bleeding include the application of PEEP, the use of topical vasoconstrictors such as ephinephrine or vasopressin, and correction of coagulation function. Other authors have recommended that the patient be placed in the lateral decubitus position with the biopsy site dependent to prevent spillage of blood into the contralateral lung. When these maneuvers fail, lung isolation with either selective endobronchial intubation using a double-lumen endotracheal tube or placement of a bronchial blocker may be useful. Successful lung isolation can be achieved with any balloon-tipped catheter such as a Fogarty occlusion catheter (a balloon-tipped catheter typically used to occlude blood vessels) or an Arndt pulmonary blocker that is typically used for one-lung ventilation. These devices are inserted into the bronchus of the lung that is the source of hemorrhage. Alternatively, as was chosen in our patient, selective intubation of the noninvolved lung may be most feasible, especially if the bleeding is from the left lung. This was chosen in our patient because it was decided that this was the quickest maneuver that might restore effective ventilation when ETCO₂ was lost. Blind selective intubation of the right lung is generally feasible, whereas bronchoscopic guidance may be required when placing a bronchial blocker or for selective left bronchial intubation. Bronchoscopic guidance may be problematic, with airway bleeding and poor visualization.

During endobronchial intubation and one-lung ventilation, substantial ventilation-perfusion mismatch should be expected. If feasible, selection of a specific bronchus vs the entire lung (as seen during use of a double-lumen endotracheal tube) minimizes the volume of perfused, nonventilated lung and will compromise pulmonary function the least. Flexible bronchoscopy, in this case, will assist in occlusion of the bronchus with such a device as well as provide selective lavage and suctioning.

When bleeding has not been controlled with these techniques, other authors have described the need to progress to more invasive measures of intervention such as angiographic transcatheter embolization of bronchial vessels, CO₂ laser bronchoscopy, Nd:YAG laser bronchoscopy, and extracorporeal membrane oxygenation. Angiography has been shown to be most valuable for therapeutic embolization in patients with massive hemoptysis due to cystic fibrosis, arteriovenous malformation, or bronchiectasis. Pulmonary lobectomy has been used as a last resort for treatment of pulmonary hemorrhage that does not respond to other therapies.

In conclusion, although CT-guided PLB is deemed a minimally invasive procedure, severe complications may occur related to bleeding or air leak, especially in a complex, chronically ill patient with a fungal infection. Emergency equipment and facilities to manage the most drastic of complications should be readily available, and the anesthesia team should have a preestablished plan of intervention to treat these potential complications.

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DISCLOSURES
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