Pulmonary Embolism Following Laparoscopic Antireflux Surgery: A Case Report and Review of the Literature
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ABSTRACT
Deep venous thrombosis and pulmonary embolism are concerning causes of morbidity and mortality in patients undergoing general surgical procedures. Laparoscopic surgery has gained rapid acceptance in the past several years and is now a commonly performed procedure by most general surgeons. Multiple anecdotal reports of pulmonary embolism following laparoscopic cholecystectomy have been reported, but the true incidence of deep venous thrombosis and pulmonary embolism in patients undergoing laparoscopic surgery is not known. We present a case of pulmonary embolism following laparoscopic repair of paraesophageal hernia. The literature is then reviewed regarding the incidence of pulmonary embolism following laparoscopic surgery, the mechanism of deep venous thrombosis formation, and the recommendations for deep venous thrombosis prophylaxis in patients undergoing laparoscopic procedures.

Key Words: Pulmonary embolism, Laparoscopic surgery, Deep venous thrombosis, Paraesophageal hernia.

INTRODUCTION
Approximately 260,000 cases of pulmonary embolism (PE) are clinically diagnosed each year in the United States; and, in the absence of prophylaxis, the incidence of fatal PE ranges from 0.1% - 0.8% in patients undergoing elective general surgical procedures. Since the introduction of laparoscopic cholecystectomy (LC), laparoscopic surgery has become the preferred therapy for patients with gallstone disease. Significant complications following LC are uncommon compared to open cholecystectomy (OC). Three prospective randomized trials comparing LC to OC suggest that the morbidity following LC is equal to or less than after OC. Deep venous thrombosis (DVT) and PE as a complication of laparoscopic surgery have been reported in multiple case reports and individual series, but incidence of DVT and PE following laparoscopic surgery is unknown. In this report, a case of pulmonary embolism after laparoscopic repair of a paraesophageal hernia is described, and a review of the literature is summarized with respect to the incidence of PE after laparoscopic surgery. Recommendations regarding DVT prevention after laparoscopic surgery are provided.

CASE REPORT
A 75-year-old obese male presented with a history of multiple episodes of severe postprandial coughing and epigastric pain over the previous several months. His past medical history was only significant for a history of cardiac arrhythmia. On physical examination, his abdominal exam was benign without organomegaly. As part of his workup by his internist, he underwent a computer tomography (CT) scan of his abdomen. The CT scan demonstrated an intrathoracic stomach with organoaxial volvulus without complete obstruction. Subsequently, the patient underwent a laparoscopic repair of the hiatal hernia (type III). The operation was uneventful, with an operative time of 5 hours and 14 minutes. Elastic stockings, intermittent pneumatic compression, and heparin (5,000U BID) were used as DVT prophylaxis. His immediate postoperative course was uneventful. He started ambulating on postoperative day (POD) 3 and was discharge on POD 6. The patient...
returned to clinic on POD 15 for a follow-up visit with a complaint of shortness of breath, low grade fever and poor appetite. A chest X-ray revealed a left-sided pleural effusion. An arterial blood gas demonstrated a $pO_2$ of 57 on room air. A venous doppler study revealed left common femoral, superficial femoral and popliteal vein thrombosis. The patient was started on a heparin drip to maintain the activated partial thrombin time at one-and-a-half time normal. A ventilation/perfusion scan revealed almost no perfusion to the right upper lobe consistent with a high probability of PE. The patient was treated with anticoagulation, supportive care and bed rest with gradual improvement of his $O_2$ saturation and bilateral lower extremity edema. He was then switched to coumadin prior to discharge. At two-year follow-up, he is doing well, off all anticoagulation.

DISCUSSION

DVT and PE following major surgical procedures remain significant causes of major morbidity and mortality. The incidence of DVT as demonstrated by fibrinogen scanning in surgical patients receiving no prophylaxis is 25%, and clinically significant PE occurs in 1.6% of surgical patients. The use of prophylactic regimens can significantly reduce the incidence of postoperative DVT and PE. Although laparoscopic surgery now composes a major part of general surgery, very little is known of the relative risk of developing complication of venous thrombosis after laparoscopic procedures. Furthermore, specific recommendations regarding prophylactic measures against DVT formation after laparoscopy are not widely appreciated. It is important to determine the incidence of DVT and PE following this emerging procedure. In addition, it is important to determine the risk factors in laparoscopic surgery, which can contribute to the development of DVT and the use of appropriate prophylactic measures in the prevention of this dreaded complication.

Factors predisposing patients to thromboembolism can be grouped into inherited and acquired factors. Inherited risk factors include antithrombin III deficiency, protein C deficiency, protein S deficiency, and dysfibrinogenemia. Acquired risk factors include malignancy, age over 40 years, immobilization, prior thromboembolism, stasis, obesity, pregnancy, sepsis, stroke, inflammatory bowel disease and prior major surgical procedures. Each individual surgical patient may have any number of these risk factors, which may cumulatively increase their risk. Apart from these well recognized predisposition conditions, several factors specific to laparoscopic surgery may increase the risk of developing DVT. Others factors specific to laparoscopy may actually decrease the risk of DVT formation. Factors which increase the risk of DVT development include $CO_2$ pneumoperitoneum, reverse Trendelenburg position, and prolonged operative time. The pressure effects of pneumoperitoneum impair lower extremity venous return leading to venous stasis. Ido et al. demonstrated a significant decrease in femoral blood velocity and an increase in female vein cross-sectional area in human patients after abdominal insufflation to 10 mm gh. Millard et al. similarly showed reduction in peak systolic velocity in the femoral vein in patients undergoing pneumoperitoneum and demonstrated that these effects can be reversed with the use of intermittent sequential pneumatic compression. The frequent use of reverse Trendelenburg position during laparoscopic surgery can also enhance venous stasis. Moneta et al. demonstrated a decrease in peak velocity of femoral vein and an increase in common femoral vein diameter when proceeding from a 10-degree head-down position to a 30-degree head-up position. The increase in operative time associated with advanced laparoscopic procedures (ie, laparoscopic Nissen fundoplication and laparoscopic colorectal surgery) can increase the duration and, thus, effect all the above-mentioned operative factors that may promote thrombosis.

Conversely, early ambulation and the potential reduction in postoperative hypercoagulation after laparoscopic surgery may decrease the risk of DVT development. LC, for example, is associated with early ambulation, while it may take several days for patients to become fully ambulatory after an open cholecystectomy. The enhanced mobility may reduce venous stasis and decrease the risk of venous thrombosis. The hypercoagulable state normally presents after major surgery has been shown to play a major role in DVT formation. Theoretically, laparoscopic surgery may blunt the hypercoagulable response due to the reduced tissue injury and stress response associated with these procedures. Initial studies show conflicting data on whether the laparoscopic methods may to some degree attenuate the hypercoagulable response. Caprini et al. demonstrated a significant postoperative hypercoagulable state in patients undergoing LC as seen by an increase in the thromboelastography (TEG) index and a significant reduction in a PTT level in the postoperative period.
strated no statistical differences in plasma concentration of interleukin-6 or various mediators of coagulation-fibrinolysis between evenly matched patients undergoing open or laparoscopic cholecystectomy. Dexter et al also demonstrated similar perioperative changes in the coagulation and fibrinolytic pathway for patients undergoing laparoscopic and open cholecystectomy. Our initial results, however, provided evidence of a blunted hypercoagulable state after laparoscopic surgery. We measured TEG in 21 pigs selected to undergo LC (N=10) or OC (N=11). A profound hypercoagulable state was evidenced by changes in 3 of 4 TEG parameters (R, K, and MA parameters) to reflect a state of hypercoagulation compared to preoperative values following OC. Swine undergoing LC, however, developed a blunted hypercoagulable state with hypercoagulable changes in only one of the TEG parameters (MA parameter). Further investigation will be necessary to clarify the importance of laparoscopy on postoperative hypercoagulation.

We present in this report a case of pulmonary embolism following laparoscopic repair of 67 paraesophageal hernias at our institution. The risk factors for venous thrombosis in this patient included age over 40 years, obesity, pneumoperitoneum, reverse Trendelenburg position, and lengthy operative time. DVT prophylaxis in this patient included the use of elastic compression stockings, intermittent pneumatic compression boots intraoperatively and postoperatively, and low-dose subcutaneous heparin. Despite these measures, he developed DVT and subsequently pulmonary embolism on POD 15. This thromboembolic complication after an advanced laparoscopic procedure raises the issue regarding the risk of DVT/PE formation after laparoscopy.

Multiple reports of DVT and PE have been described in the literature following laparoscopic cholecystectomy.
Pulmonary Embolism Following Laparoscopic Antireflux Surgery: A Case Report and Review of the Literature, Nguyen NT, et al.

Table 3. DVT/Pulmonary Embolism following Laparoscopic Nissen Fundoplication and Laparoscopic Paraesophageal Hernia Repair (PEH).

| Author             | Year        | Number of Patients | Number of DVT/PE (%) |
|--------------------|-------------|--------------------|----------------------|
| Pitcher et al.     | 1994-Nissen | 70                 | 1 DVT (1.43%)        |
| Jamieson et al.    | 1994-Nissen | 155                | 4 PE (2.58%)         |
| Collard et al.     | 1994-Nissen | 39                 | 1 PE (2.56%)         |
| Zaninotto et al.   | 1995-Nissen | 41                 | 0 PE (0.00%)         |
| Watson et al.      | 1995-Nissen | 230                | 4 PE (1.74%)         |
| Gotley et al.      | 1996-Nissen | 200                | 1 PE (0.50%)         |
| Sataloff et al.    | 1997-Nissen | 20                 | 2 PE (10.00%)        |
| Huntington         | 1997-PEH    | 58                 | 1 PE (1.72%)         |
| Perdikis et al.    | 1997-PEH    | 65                 | 1 PE (1.54%)         |
| Willekes et al.    | 1997-PEH    | 30                 | 1 PE (3.33%)         |
| Total              |             | 908                | 16 PE (1.76%)        |

Table 4. DVT/Pulmonary Embolism following Laparoscopic Colorectal Surgery.

| Author             | Year | Number of Patients | Number of DVT/PE (%) |
|--------------------|------|--------------------|----------------------|
| Guillou et al.     | 1993 | 59                 | 2 PE (3.39%)         |
| Rhodes et al.      | 1996 | 84                 | 2 PE (2.38%)         |
| Kwok et al.        | 1996 | 83                 | 1 PE (1.20%)         |
| Lumsley et al.     | 1996 | 240                | 1 PE (0.42%)         |
| Gellman et al.     | 1996 | 102                | 1 PE (0.98%)         |
| Begos et al.       | 1996 | 50                 | 0 PE (0.00%)         |
| Milsom et al.      | 1998 | 55                 | 1 PE (1.82%)         |
| Köckerling et al.  | 1998 | 500                | 0 PE (0.00%)         |
| Total              |      | 1,173              | 8 PE (0.68%)         |

laparoscopic Nissen fundoplication and laparoscopic colorectal surgery. Table 1 lists all reported series in a single institution with DVT or PE described as a complication of LC. The mean incidence of PE among these single institutional series that report PE as a complication is 0.139%. This value is only an estimate, and caution is necessary in interpreting these data since there is tremendous variability in describing the types and range of complications among different studies. Some studies provide an exhaustive list of complications, while others only provide a limited list. In addition, it is difficult to know if DVT and PE occurred in a series that did not report these complications in their report. We only considered studies that specifically stated DVT or PE as a complication of the procedures—thus excluding studies in which no DVT or PE was reported. The incidence of PE following laparoscopic cholecystectomy is comparable to other reported incidences of open cholecystectomy. Berci et al. reported a 0.167% incidence of PE following 1,200 open cholecystectomies, and Shea et al. reported an incidence of 0.31% following 1,611 open cholecystectomies. Table 2 lists the incidence of PE/DVT as reported in a multiple institution series of laparoscopic cholecystectomy. This incidence of PE ranged between 0.004% - 0.329%, with a mean incidence of 0.018%. Table 3 lists all studies with DVT or PE reported as a complication following laparoscopic Nissen fundoplication and laparoscopic paraesophageal hernia repair (PEH). The incidence of PE is estimated to be 1.76%. This number is significantly higher than the described incidence for patients undergoing LC. This may be due, in part, to the prolonged operative time associated with this advanced laparoscopic procedures. Table 4 lists studies that report DVT and PE as a complication following laparoscopic colorectal surgery. The number of reported laparoscopic colorectal procedures is small compared to LC and laparoscopic antireflux surgery. The incidence of PE in this group ranged from 0.00% - 3.39%, with a mean incidence of 0.68%. Additional risk factors for development of DVT in this group of patients are the presence of malignancy, advanced age and prolonged operative time.

Data from randomized control trials have shown that prophylaxis in general surgical patients reduces the incidence of DVT at least by half compared to control patients. Randomized trials of low-dose heparin showed a 68% reduction in DVT and a 49% reduction in PE. There was also a reduction in the mortality associated with PE.

Currently, the recommended modality of DVT and PE prevention in patients undergoing general surgery and laparoscopic surgery are categorized according to the risk classification. Caprini et al. developed a Risk Assessment System to determine criteria for instituting prophylaxis and the appropriate regimen for a given patient. This system is based on a scoring system containing 20 clinical risk factors. For low risk general surgery patients (0-1 factor), early ambulation and elastic...
stocking are recommended. For moderate risk patients (2–4 factors), either low-dose heparin or a combination of elastic stocking and intermittent pneumatic compression is advocated. For the high risk group (>4 factors), a combination of heparin, elastic stocking and pneumatic compression is recommended. According to the Caprini DVT Risk Assessment System, most patients undergoing laparoscopic surgery will fall into the category of moderate or high risk and, therefore, will require DVT prophylaxis in the form of low-dose heparin or pneumatic stockings. Although these guidelines for DVT prophylaxis are not validated by prospective studies, they constitute a rational approach that is currently applicable until further investigation yields alternative recommendations.

Conditions specific to laparoscopic surgery may profoundly impact normal physiologic mechanisms of coagulation and thrombosis. Based on the current literature, it is unclear whether laparoscopic surgery results in an increase or decrease in the rate of DVT formation. Retrospective studies show similar incidences of DVT/PE in both open and laparoscopic cholecystectomy but slightly higher incidences following more advanced laparoscopic procedures, like laparoscopic Nissen fundoplication and paraesophageal hernia repair. Well-controlled prospective studies are lacking. Until reliable data regarding DVT incidence after laparoscopy are available, it is prudent to assume that laparoscopy carries an added risk. Liberal application of DVT prophylaxis for laparoscopic procedures thus seems warranted. The prevention and management of thromboembolic complications in this rapidly expanding era of modern laparoscopic surgery constitutes an important issue that requires more attention and investigation.

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