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Research Article

Pulmonary Air Embolism (PAE): Complication during TaTME is a Cause for Concern

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Abstract

The transanal approach to performing total mesorectal excision (TME) for both rectal cancer and inflammatory IBD has grown significantly over the last decade. In spite of the known relatively commoner complications associated with this approach to the rectum, the increase in surgical volume allows for evaluation and stratification of less frequent complications such as embolism. We present a review article on the very limited studies available on the incidence of PAE occurring during taTME.

Keywords: Pulmonary Air Embolism; Transanal Total Mesorectal Excision; Refractory Ulcerative Colitis

Introduction

Over the last few decades, minimally invasive surgery has gained tremendous popularity among surgeons due to the improvement in technique, better instrumentation and subsequent outcomes [1,2]. Preliminary data from performing TME using a transanal approach has been promising so far [2], however when complications arise they certainly trend towards greater morbidity for these patients [3].

Overall, the incidence of PAE during laparoscopic surgical procedures is reported to be 15 per 100,000 cases per year [1]. Ratcliffe., *et al*. described the first case of PAE during taTME [1,3]. Typically, PAE manifests primarily with cardiopulmonary instability [3]. A rapid reduction of end-tidal carbon dioxide ($ETCO_2$), oxygen saturation (SpO_2), and blood pressure (BP) in the face of a raised partial pressure of arterial carbon dioxide ($PaCO_{2)}$ should alarm surgeons and anesthetists about the possibility of evolving PAE [3].

Discussion and Conclusion

PAE is a result of interaction among source of air, vasculature, and the pressure gradient favoring the passage of air into the circulation [4,5]. One of the possible mechanism of PAE during taTME is the CO_2 entrapment in the lower venous pressure rectal vessels [3]. With the patient in the Trendelenburg position, the operating site in the taTME is above the heart level, which along with the low venous pressure in rectal vessels further facilitates the CO_2 entrapment [3]. Also, the anesthesia-related vasodilation makes it easier for the CO_2 emboli to enter the circulation [3]. Additionally, venous laceration during laparoscopic dissection is a common predisposing factor for PAE [6]. The anatomy of the presacral region with bleeding vessels poses an enormous risk for the PAE in a patient undergoing taTME [3].

Furthermore, the guidelines regarding the volume and pressure settings of CO_2 insufflation to establish and maintain the adequate

pneumorectum are not well established. The cases described above are unique as they are the perfect blend some of the theories mentioned above. In both cases described, bleeding from the prostatic venous plexus was noticed during the transanal phase of taTME, which along with the variable insufflator settings to maintain the pneumorectum and Trendelenburg position of the patient at the time of surgery, could possibly explain the onset of PAE in our patients.

The pathophysiological manifestation of the PAE depends not only on the nature of the gas used but also on the rate of gas entry into the circulation [7]. The CO_2 absorbed into the circulation leads to hypercarbia which ultimately leads to acidosis [8]. Slow leakage of air into circulation leads to partial occlusion of the pulmonary vasculature, resulting in initial compensatory increased cardiac output followed by decreased output due to the fatigue of cardiac muscle [1,8]. A massive air embolism can cause complete occlusion of the pulmonary vasculature resulting in acute heart failure and cardiac arrest a condition also known as "gas block" [1,8].

Additionally, diagnosing PAE is often challenging since most of the air is rapidly absorbed by the time diagnostic tests are arranged [9]. Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) are the gold standard modalities most widely used to diagnose PAE [10,11]. Nonspecific tests which can provide valuable information but not as specific as TTE and TFF regarding the diagnosis of PAE include $ETCO_2$, pulmonary artery catheterization, ventilation-perfusion (V/Q) scanning, chest computed tomography (CT), and pulmonary angiography [12].

Maintaining a high degree of suspicion in patients with underlying risk factors is the most crucial step in patient management [12,13]. Based on the high index of clinical suspicion, some essential life-saving maneuvers should be promptly initiated. Immediately aborting the procedure, administering high flow 100% oxygen, infusing high volume normal saline, placing the patient in left lateral decubitus position are the crucial steps in the management of PAE [14,15]. Once these maneuvers are immediately implemented, further tests to evaluate the cause of PAE can be performed.

Based on our experience, we firstly propose that in patients with bleeding vessels during the transanal phase of TME with deranged vital signs should alarm physicians regarding the possibility of impending PAE and extreme care must be taken. Secondly, adequate hydration and proper patient positioning of high-risk patients can likely reduce the incidence of PAE during taTME. Thirdly, consultation with leading colorectal surgeons nationally and internationally to develop uniformly accepted insufflators setting for adequate pneumorectum in high-risk patients for PAE will be a key milestone.

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