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Research article

The corona mortis: is it a rare and dangerous anomaly in adolescents undergoing periacteabular osteotomy?

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ABSTRACT

The corona mortis (CM) is a vascular connection between the obturator and external iliac or internal epigastric vessels that has historically been identified as a source of hemorrhage in pelvic surgery. However, its frequency, location, proximity to the osteotomies performed, vascular contributions and impact on blood loss in patients undergoing periacetabular osteotomy (PAO) are unknown. We sought to identify the frequency, origin, location relative to osteotomies performed during surgery and impact on blood loss of the CM. Preoperative magnetic resonance imaging (MRI) of the hips of 28 adolescent patients (56 hips) undergoing PAO was retrospectively reviewed for the presence of a CM. When identifiable, the size, nature (arterial or venous), orientation, position relative to the iliopectineal eminence (IPE) and associated estimated blood loss (EBL) were recorded. 75% (21/28) of patients possessed an identifiable, ipsilateral CM to the site of PAO, 90% of which were venous and 10% arterial. The vessel was typically 8.3 ± 3.8 mm medial and 11.1 ± 5.3 mm caudal from the anterosuperomedial edge of the IPE. There was no significant difference in the amount of EBL (519 ± 260 versus 694 ± 369 ml) or need for post-op transfusions (1/21 versus 0/7) between patients who possessed a CM and those who did not, respectively ($P = 0.21$). CM was more prevalent in this study than previously reported. However, the presence of an ipsilateral CM was not associated with an increase in EBL or transfusion during routine PAO surgery using modern surgical techniques.

INTRODUCTION

The corona mortis (CM) is a vascular connection between the obturator and external iliac or internal epigastric vessels (Fig. 1). The CM has been previously identified as a possible source of catastrophic hemorrhage in orthopedic pelvic surgery [1–9]. Injury to the CM has also been associated with significant hemorrhage and hemodynamic instability in a wide variety of procedures including the Tension-free vaginal tape (TVT)-Secur procedure [10, 11], inguinal hernia repairs [12, 13], repair of displaced acetabular fractures [14] and even minimally invasive mid-urethral sling procedures [15]. Several additional studies have recommended surgeons be cautious of this vessel when operating in its proximity [2, 5, 16]. However, no prior study has specifically investigated whether the presence of a CM is associated with an increased risk of transfusion or blood loss during the Ganz/Bernese periacetabular osteotomy (PAO) as it is not visualized routinely during dissection through the Smith–Peterson interval. Further, the increased proximity of the CM during alternate surgical exposures, such as the Stoppa or the middle window of the ilioinguinal approach, may place the CM at increased risk when performing PAO as direct visualization of the external iliac vascular contribution may be difficult despite the visualization of the CM. [17]. When using the modern approach to PAO, errant retractor or osteotome placement deep to the iliopsoas fascia during the posterior column osteotomy or the superior ramus osteotomy could also injure the CM. Such an injury would be difficult to visualize once the osteotome is withdrawn yet still result in significant and ongoing blood loss [18, 19]. The reported prevalence of the CM has varied widely, but two systematic reviews reported a prevalence of (49.3%) and 46% in a given hemipelvis, with a venous connection between the external iliac vessels or the inferior epigastric vessels and the obturator vessels being more common than arterial [12, 16]. However, its exact frequency, location, relationship to the osteotomies performed, vascular contributions and impact upon blood loss in patients undergoing PAO (Fig. 2) are unknown. Due to concerns regarding the potential risk of severe hemorrhage during PAO surgery, we wanted to know if the presence of a CM in a patient undergoing PAO was associated with increased blood loss or known injury to the CM. Thus, in a group of adolescent patients undergoing PAO, we sought to identify the frequency, location and vascular contributions of the CM, as well as

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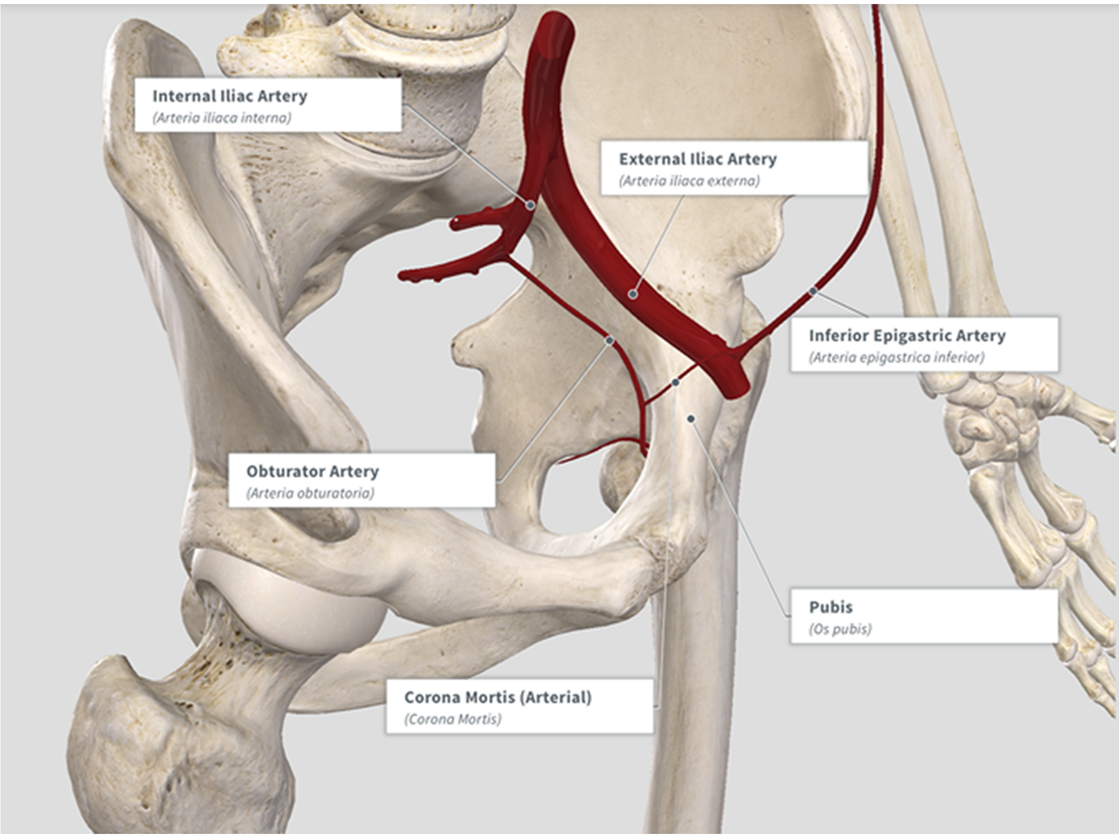

Fig. 1. Anatomical location of the arterial CM in relation to surrounding vasculature. Image courtesy of Complete Anatomy.

proximity to osteotomies performed during surgery, and to compare estimated blood loss (EBL) in the presence or absence of a CM.

MATERIALS AND METHODS

Consecutive patients <18 years of age undergoing PAO underwent preoperative magnetic resonance imaging (MRI) on a 3.0T MRI system (Philips, Best, the Netherlands or General Electric, Wauwatosa, WI, USA) that included a high-resolution essentially isovolumic voxel 3D fast or turbo spin echo proton density sequence without fat saturation of the entire pelvis including both hips. Images of each hip in all patients were reviewed using a multiplanar picture archiving and communication system (PACS) workstation by a senior musculoskeletal radiologist without knowledge of operative blood loss for the presence of a CM vessel. When identifiable, the diameter, arterial versus venous contributions, laterality, horizontal versus vertical course (Fig. 3) and location in relation to the iliopectineal eminence (IPE) (Fig. 4) of the 56 hips (28 patients) were recorded. EBL and peri-operative transfusion were also recorded for all patients. Cell saver was utilized in all cases, and patients routinely underwent a fascia iliaca nerve block–based peri-operative pain protocol.

PAO was performed using a contemporary technique. A standard ‘bikini’ incision followed by superficial and deep dissection was performed using the Smith–Peterson interval. The standard osteotomies described for the procedure were made [20]. Subperiosteal dissection was performed during the approach and retractor placement for the superior ramus osteotomy and while dissecting along the inner table of the pelvis with subsequent retraction of the iliacus and psoas muscles and fascia medially during the posterior column osteotomy.

The mean values for the frequency, location, diameter and vascular contributions of the CM were determined. Statistical differences in EBL and need for transfusion between patients with and without a CM were calculated.

RESULTS

28 patients (27 females) met inclusion criteria and 56 hips were evaluated. The mean age was 15.7 ± 1.8 years. We were able to identify an ipsilateral CM on the MRI in 21/28 (75%) of patients. 19/21 (90%) were venous and of mean diameter 2.2 ± 0.8 mm. 18/21 (86%) patients with a CM ipsilateral to the site of PAO had a contralateral CM, while only 1/7 (14.3%) without an ipsilateral CM had a contralateral CM. The structure/s were most commonly located approximately 8.3 ± 3.8 mm medial and 11.1 ± 5.3 mm caudal from the anterosuperomedial edge of the IPE, as depicted in Fig. 4. There were no significant differences in the EBL (519 ± 260 versus 694 ± 369 ml, $P = 0.21$) or increased need for post-op transfusion (1/21 versus 0/7) in patients with or without an ipsilateral CM, respectively.

DISCUSSION

Due to concerns regarding severe hemorrhage during PAO surgery, we wanted to know if the presence of a CM in

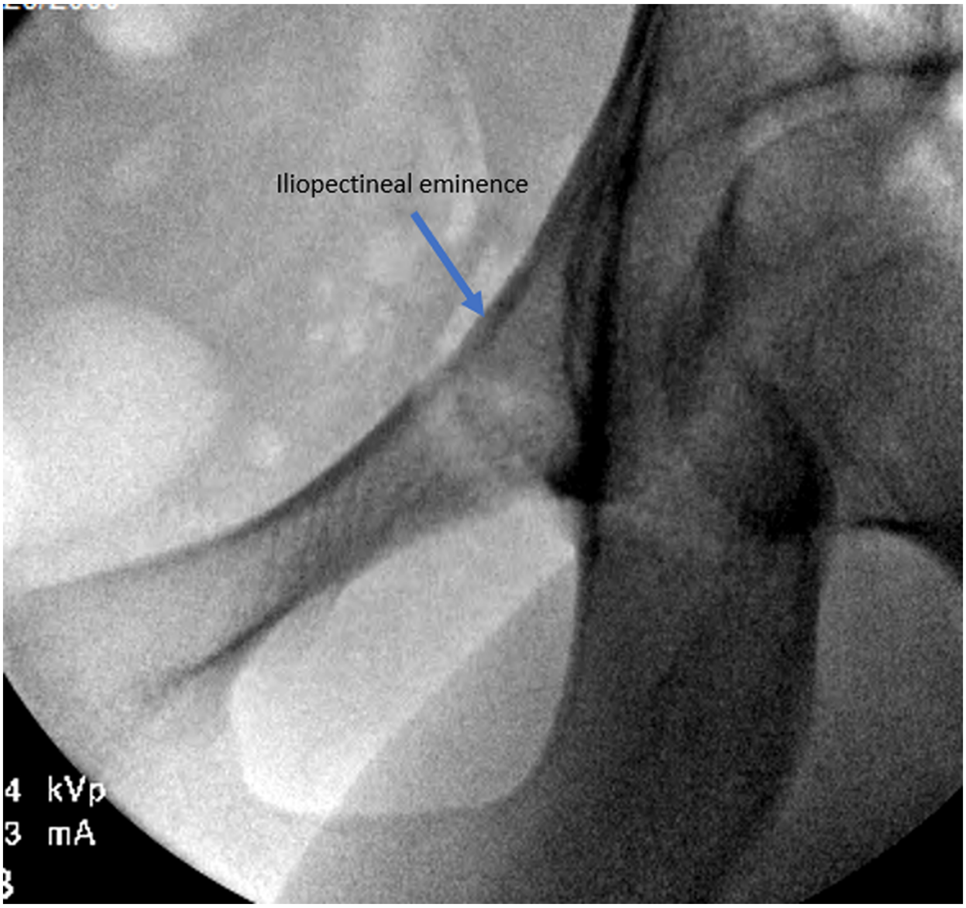

Fig. 2. Location of IPE proximal to the superior pubic ramus osteotomy.

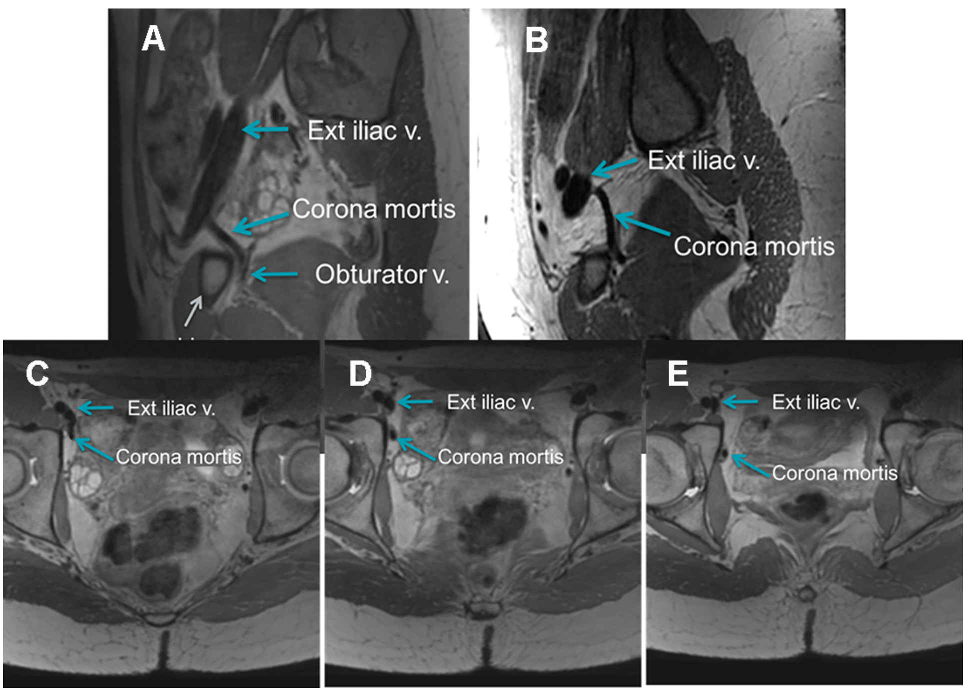

Fig. 3. (a and b) Sagittal MRI images of orientations of venous CM. (a) Horizontal CM. (b) Vertical CM. (c–e) Axial MRI images of CM.

Fig. 4. 3D-CT reconstruction of right hip.

an adolescent patient undergoing PAO was associated with increased blood loss or need for transfusion. Thus, we sought to identify the frequency, location and vascular contributions of the CM, as well as proximity to osteotomies performed during surgery, and to compare estimated blood loss and need for transfusion in the presence or absence of a CM. PAO surgery has become the most common treatment for symptomatic pre-arthritic developmental dysplasia of the hip in adolescent and young adult patients. It has been associated with positive outcomes including pain relief and improved hip function in the short term [21] and hip preservation in as many as 61% of patients after 20 years [22]. However, the surgery also comes with a variety of complications, both major and minor. The most common major complications include acetabular fragment migration, surgery for deep infection and thromboembolic complications, whereas the most common minor complication is asymptomatic heterotopic ossification [23]. Other concerns during the surgery include vascular or nerve injuries. Transient lateral cutaneous nerve injury is very common but most often resolves within a year, whereas injury to the sciatic and femoral nerve are rare, occurring in only 36/1760 (2.1%) [24] and 8/643 (1.24%) of patients [25]. Injury to the CM has been reported in a variety of different pelvic surgeries in addition those in orthopedics. There are multiple cases where the CM was reportedly injured over Cooper's ligament either via cautery [26] or during fixation of mesh into the ligament [12, 27]. These injuries typically lead to life-threatening hemodynamic instability, necessitating a return to the operating room to achieve hemostasis.

Prior studies have reported vascular injuries of the obturator artery when the ramus osteotomy is performed in its proximity necessitating intervention during PAO [28, 29]. Although anecdotal reports of vascular injuries during PAO exist in the community, there is a paucity of reported vascular injuries during the Ganz or Bernese PAO in the available literature [18, 28]. Due to the potential for vascular injury associated with the CM during the Ganz/Bernese PAO, we sought to identify its frequency, vascular contributions, location relative to osteotomies performed during surgery and impact on blood loss and transfusion in our patient population.

In this study, 75% of hips possessed a CM ipsilateral to the hip which underwent PAO. The CM was commonly bilateral (86%) and venous in nature (90%). No statistically significant increase in blood loss or need for post-op transfusion was associated with a CM. However, when performing PAO through alternative surgical intervals or when performing the posterior column or ramus osteotomies near the IPE, care should be taken to ensure that the osteotome or other instruments remain subperiosteal and do not penetrate the iliac fascia as this may result in iatrogenic injury to the CM. Such injury may not be recognized at the time it occurs. In this study, the original and contemporary modifications of Mast and Ganz's technique were not associated with increased EBL or need for transfusion when performed in patients who possess a CM. We believe that this is likely due to the subperiosteal dissection of the inner table of the pelvis and retraction of the iliacus, psoas and soft tissue structures medial to the ramus and posterior column during osteotomy.

There are many limitations to this study. Type II error regarding the EBL and transfusion likely exists as the number of transfusions was low and there was a large standard deviation to the EBL in each group, both of which were small in number. We were unable to determine if there was a difference in size between the venous versus arterial CMs for similar reasons. As stated in the "Materials and Methods" section, we only listed a CM that was identifiable without any artifact. Thus, the percentages given reflect a minimum incidence of the CM in this group as four of the hips were difficult to clearly identify its presence due to artifact. These hips were included as an absence in our calculation. Further, only one technique for PAO was evaluated. Performing PAO through alternative intervals (middle window, extra-periosteal through the psoas bursa and differing levels of retraction or patient positioning) may result in different observations. Our patient population may not represent those patients at greatest risk regarding anatomical variation, the presence of intra- or extra-peritoneal prior surgery, soft tissue disorders and friability, prior infection and the presence of fascial or muscle tears which may be associated with an increased risk. We also examined only an adolescent population which may recover from increased blood loss and thus we may have been biased to transfuse these patients less than those of an adult population with more medical co-morbidities or fatigue post-operatively. Last, we did not observe a vascular injury in our population particularly in patients with a high EBL. While our method of detection may not be sensitive to injuries, no abnormal bleeding was observed during surgery or in the post-operative period to suggest an occult injury to the CM or other vessels. The authors submit that this is not a reliable means of assessing injury and that a more standardized means of determining EBL and or vascular damage peri-operatively would be more definitive with regard to our conclusions. A multi-center study including alternative surgical approaches or patients with a more extensive history of surgery or anatomic abnormalities in the areas of concern may produce different results. However, to date, large multi-center cohorts have not identified hemorrhage due to CM injury as an actual risk despite its proximity to the osteotomies described. This is attributable to the technique as developed by Mast and Ganz and its contemporary iterations.

PAO appears safe using established surgical techniques in the presence of a CM. However, variations in dissection, retractor placement accompanying anatomic abnormalities, prior extra- or intra-peritoneal surgery during osteotomy of the superior pubic ramus and the posterior column medial and caudal to the IPE could cause its disruption leading to iatrogenic hemorrhage. Knowledge of the anatomic location of the CM may help surgeons to minimize potential complications related to its injury.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, AWH, upon reasonable request.

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None declared.

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