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Portomesenteric venous thrombosis following major colon and rectal surgery: incidence and risk factors

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Abstract
Background Portomesenteric venous thrombosis (PMVT) is an uncommon complication of abdominal surgery. The objective of this study was to assess PMVT risk factor profiles and patient outcomes after colorectal surgery.
Methods A single center retrospective review of patients undergoing colorectal surgery was performed (2007–2012). PMVT was defined as thrombus within the portal, splenic, or superior mesenteric vein on computed tomography (CT). Inferior mesenteric vein thrombosis was excluded. Independent samples *t* test was used to compare data variables between PMVT and non-PMVT patients. Univariate and multivariate logistic regression analyses were used to assess PMVT risk factors.
Results There were 1,224 patients included (mean age 62 years, male = 566). Elective bowel resection was performed for colon carcinoma ($n = 302$), rectal carcinoma ($n = 112$), ulcerative colitis ($n = 125$), Crohn's disease ($n = 78$), polyps ($n = 117$), and diverticulitis ($n = 215$). Patients undergoing gynecological resections and emergent laparotomies were included ($n = 275$). Thirty-six patients (3 %) were diagnosed with PMVT by CT: 17/36 on initial presentation and 19/36 by expert radiologist review. Patients with PMVT were younger (53 vs. 62 years, $p = 0.001$) with higher BMI (30.5 vs. 26.7, $p < 0.001$) and thrombocytosis (464 vs. 306, $p < 0.001$) compared to patients without PMVT. Univariate logistic regression identified younger age ($p < 0.001$), obesity ($p < 0.001$), ulcerative colitis ($p < 0.001$), thrombocytosis, ($p < 0.001$) and proctocolectomy as significant predictors of PMVT. Stepwise multivariate logistic regression identified that obesity ($p < 0.001$), thrombocytosis, ($p < 0.001$) and restorative proctocolectomy ($p = 0.001$) were still significant predictors. No patients in the PMVT group suffered bowel infarction and no related mortalities occurred. Thirty-day readmission rates were higher in the PMVT group (53 % vs. 17 %, $p < 0.01$).
Conclusion BMI ≥ 30 kg/m^2, thrombocytosis, and restorative proctocolectomy were significant predictors of PMVT. Initial diagnostic studies showed a PMVT rate of 1.4 %; however, after expert focused radiologic review, the actual rate was 3 %. Thus, the diagnosis of PMVT is difficult and readmission after colorectal surgery should prompt its consideration.

Keywords Portomesenteric venous thrombosis · Colorectal surgery · Abdominal DVT · Risk factors · Inflammatory bowel disease

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The portomesenteric venous system is comprised of the portal vein (PV), splenic vein (SV), superior mesenteric vein (SMV), and inferior mesenteric vein (IMV). Life-threatening complications from thrombosis of this system have been recognized and treated since the late 19th century [1].

Fig. 1 Axial images of an abdominal CT showing acute thrombus of the right portal and superior mesenteric veins diagnosed in a patient 16 days after laparoscopic right colectomy

Portomesenteric venous thrombosis (PMVT) may present de novo in patients with underlying thrombophilia or following provocation with abdominal surgery (Fig. 1). PMVT sequelae range from non-specific abdominal pain to life-threatening complications as a result of venous congestion and subsequent intestinal infarction or ischemia. PMVT may also be an incidental finding following radiological imaging [2].

Ogren et al. reported a 1 % PMVT prevalence from their population study based on 23,796 autopsies [3]. Although PMVT remains uncommon, an increased incidence has been described in certain patient subgroups including those with inflammatory bowel disease (IBD) (1–29 %), myeloproliferative neoplasm (MPN) (15–30 %), malignancy (4–16 %), and cirrhosis (2–26 %) [4–14]. However, PMVT data in the broader surgical population are lacking [15, 16].

Historical data indicate that PMVT accounts for 0.01 % of acute surgical abdomens and 0.002–0.06 % of all inpatient admissions [17–19]. Predisposing risk factors relate to direct locoregional effects or systemic hypercoagulability. Locoregional effects include abdominal malignancy, trauma, inflammation, and factors altering portal venous blood flow such as cirrhosis and surgery [20]. Systemic factors include inherited prothrombotic states (antithrombin III deficiency, factor V Leiden mutation, protein C and S deficiency, and G20210A prothrombin mutation) and acquired prothrombotic states (sepsis, oral contraceptive use, and MPN) [11, 20]. Patients with cirrhosis and hepatic carcinoma are suggested to have the highest risk of PMVT development while obesity and surgical intervention have also been shown to increase prothrombotic risk [3, 16, 20–23]. Certain surgical procedures are shown to have a higher PMVT incidence, particularly proctocolectomy and splenectomy, where extensive manipulation of mesenteric vessels and ligation of the splenic vein increase overall PMVT risk [23] [24]. It is postulated that laparoscopy may increase PMVT risk due to alterations in portovenous blood flow by increased intraabdominal pressure from pneumoperitoneum, reverse Trendelenburg positioning, and splanchnic vessel manipulation [20]. Even intermittent decompression of the pneumoperitoneum during laparoscopy has been suggested to abate decreased blood flow to the superior mesenteric artery and PV [25].

Treatment modalities for PMVT relate to severity of clinical sequelae. Systemic anticoagulation is recommended for symptomatic splanchnic vein thrombosis [26]. The use of anticoagulation in acute PMVT is supported by data that suggest recanalization occurs with treatment more often than without, thus reducing the risk of intestinal infarction and complications of chronic PMVT (Fig. 2). Studies also show lower recanalization rates in patients with extensive thrombus of the portal venous system compared to those with isolated thrombosis of the PV or SMV [27]. Although endovascular modalities with catheter directed thrombolysis or mechanical thrombectomy are potential therapeutic options, hemodynamic instability, intestinal ischemia and sepsis warrant surgical intervention [11, 28]. Acosta et al. reported a 19.6 % 30-day mortality during a retrospective review of 51 patients with mesenteric vein thrombosis [28].

Current incidence and risk factors for PMVT development after major abdominal surgery, particularly colon and rectal procedures, are lacking. This surgical population encompasses many of the proposed PMVT risk factors including laparoscopic approach, splanchnic vasculature manipulation, extreme positioning, abdominal malignancy, and IBD. The main objectives of this study were to evaluate PMVT incidence, risk factors, operative course, and patient outcomes following major colon and rectal resections in a high volume tertiary referral center.

Methods

Institutional review board approval was obtained. Clinical billing information using ICD-9 procedure codes, CPT

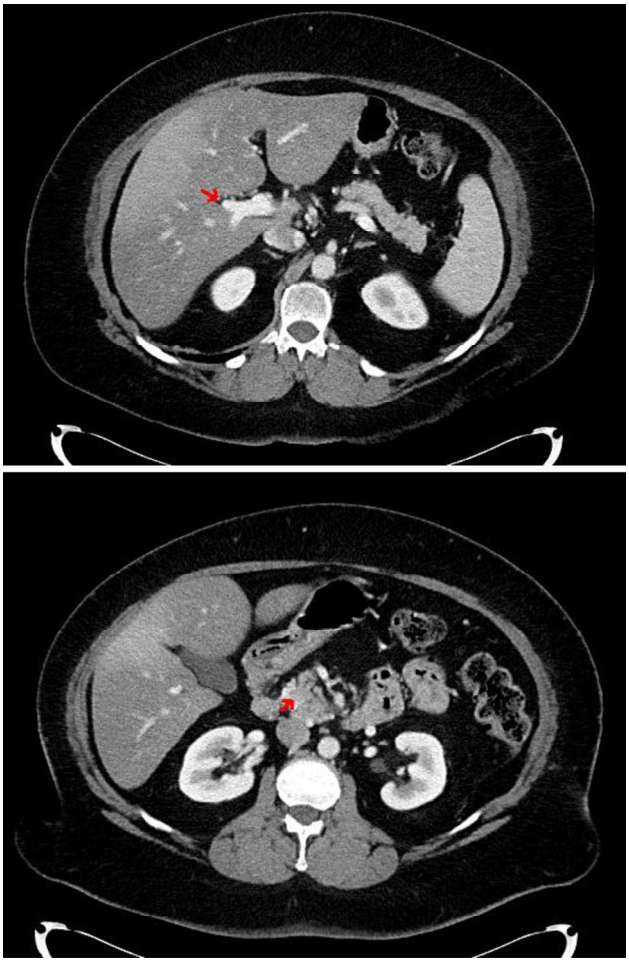

Fig. 2 Follow-up abdominal CT of the same patient showing recanalization of the right portal vein and chronic thombosis of the superior mesenteric vein after 3 months of anticoagulation with warfarin therapy

codes, and DRGs was interrogated to collate a database of all patients undergoing colon and rectal surgery at the Mayo Clinic Arizona (MCA) from January 2007 to December 2012. Data collected from electronic medical records included patient demographics, clinical history including previous prothrombotic events, type of procedure and indication, intraoperative and postoperative course, readmission rate and date of death from any cause if applicable. For the purpose of this study, we analyzed laparoscopic conversions to open surgery as members of the laparoscopic group due to the presence of pneumoperitoneum and consideration of extreme patient positioning. All radiological imaging performed prior to the patient's 10-week post-operative clinic visit were examined for the presence of PMVT.

Hematologic analysis of maximum platelet count for the hospitalization and platelet count on the day of PMVT diagnosis was recorded. PMVT was defined as thrombus within the portal, splenic, or superior mesenteric veins. Inferior mesenteric vein thrombosis without extension of clot to adjacent veins was excluded. Specific CT data reported the presence of PMVT and extent of vessels involved. Follow-up imaging reports to assess clot evolution were reviewed when available. All CT images performed post-operatively were subsequently re-analyzed by a Board-certified radiologist (JSK) to assess for previously unrecognized PMVT. The presence of PMVT was divided into those identified on the first radiological report versus those found on subsequent focused assessment.

Statistical analysis was performed using SPSS version 17.0. A Q–Q test confirmed parametric distribution. Descriptive statistics included mean and range. Independent *t* test was used to compare data variables between PMVT and non-PMVT patient groups. Univariate and multivariate logistic regression analyses were used to assess the effect of clinical characteristics on PMVT rate. Chi square test was used to evaluate readmission rates between groups and Fisher's exact test was used for subgroup analysis of patients with PMVT diagnosed on initial imaging and PMVT patients who were diagnosed on subsequent radiological review. A p-value < 0.05 was considered significant.

Results

Patient demographics

There were 1,224 patients included (male = 566) with a mean age of 62 years (range, 18–97). Bowel resection was performed electively for colon carcinoma ($n = 302$), rectal carcinoma ($n = 112$), ulcerative colitis (UC) ($n = 125$), Crohn's disease ($n = 78$), polyps ($n = 117$), diverticulitis ($n = 215$) or during gynecological resections and emergent laparotomies ($n = 275$).

The majority of patients were Caucasian ($n = 1{,}136$) and 213 (17 %) had a body mass index (BMI) greater than 30 kg/m^2. One hundred and eight patients (9 %) were current smokers and 11 patients (1 %) had diagnosed hypercoagulable disorders including factor V Leiden ($n = 5$), protein C or S deficiency ($n = 1$), antiphospholipid syndrome ($n = 3$), polycythemia vera ($n = 1$), or multiple etiologies ($n = 1$). History of extremity deep venous thrombosis (DVT) was present for 52 patients (4 %) and 28 (2 %) had a history of a pulmonary embolism (PE). Anticoagulation for treatment of previous thromboembolic events was prescribed for 18 patients (2 %) at the time of surgery. Comparison of patient demographics and clinical characteristics between the PMVT and non-PMVT group is shown in Table 1.

In total, 338 patients (28 %) were prescribed pre-operative anticoagulation regimens for atrial fibrillation, prosthetic heart valves, coronary and/or peripheral arterial disease, or history of thromboembolic events. Antiplatelet

Table 1 Comparison of patient demographics and perioperative characteristics

Demographics	PMVT $N = 36$	Non-PMVT $N = 1,188$	p value
Age, years (range)	52.7 (27–82)	61.9(17–97)	<0.001*
Gender- Male	17	549	0.91
Race- Caucasian	34	1,102	0.95
BMI, kg/m^2	30.5 (20.7–42.5)	26.7 (13.0–54.2)	<0.001*
Smoking	4	104	0.62
History of DVT	2	50	0.82
History of PE	2	26	0.24
Hypercoagulable disorder	1	10	0.34
Baseline antithrombotic use	10	328	0.98
Pre-op DVT prophylaxis	35	1,058	0.20
Post-op DVT prophylaxis	30	1,082	0.10
Surgical indication			
Crohn's disease	1	77	0.37
Ulcerative colitis	11	114	<0.001*
Diverticulitis	4	211	0.30
Colon cancer	9	293	0.96
Rectal cancer	2	110	0.45
Polyps	4	113	0.75
Cancer	13	462	0.74
Operative characteristics			
Left colectomy	28	790	0.16
Right colectomy	8	398	0.16
Restorative proctocolectomy	11	91	<0.001*
Proctectomy	0	55	0.19
Open	13	468	0.69
Laparoscopic	23	720	0.69
Surgery length, min	244 (32–595)	234 (40–905)	0.27
Intra-operative hypotension	22	616	0.27
Intra-operative blood transfusion	4	115	0.70
Outcomes			
Post-operative hypotension	19	564	0.53
Post-operative blood transfusion	11	216	0.05
Maximum platelet level	465 (99–1,181)	306 (33–1,320)	<0.001*
30-day readmission	19	202	<0.01*
Overall survival	35	1,008	0.04*

* indicates statistical significance

agents included aspirin ($n = 235$) or clopidogrel ($n = 8$) and anticoagulants included warfarin ($n = 42$) or others ($n = 8$). Combination therapy was prescribed for 19 patients and 26 were bridged with heparin or low-molecular weight heparin pre-operatively. Only 18 patients (2 %) had undergone previous organ transplantation, the most common being renal transplant ($n = 10$).

Operative intervention and clinical course

All patients had standard mechanical thromboprophylaxis including knee-level compression hosiery and sequential compression devices. The majority of patients (84 %) received perioperative thromboembolic chemoprophylaxis with subcutaneous unfractionated heparin or low-molecular weight heparinoids. The remaining patients did not receive chemoprophylaxis because of the emergent nature of the surgery or due to concerns of bleeding diathesis.

Procedures performed included right colectomy ($n = 307$), left colectomy ($n = 69$), sigmoidectomy ($n = 282$), total colectomy ($n = 113$), proctectomy ($n = 55$), ileocolic resection ($n = 99$), abdominoperineal resection ($n = 36$), restorative proctocolectomy with ileal pouch anal anastomosis (IPAA) ($n = 92$), low anterior resection ($n = 92$), transverse colectomy ($n = 20$), proctocolectomy

Table 2 Post-operative CT scan indications and locations of PMVT

Post-operative CT indication	Diagnosed PMVT $N = 17$ (%)	Missed PMVT $N = 19$ (%)	p value
Abdominal pain	6 (35)	8 (42)	0.74
Rule out anastomotic leak	3 (18)	3 (17)	1.00
Leukocytosis	3 (18)	1 (5)	0.34
Rule out bleeding	1 (6)	1 (5)	1.00
Fever	1 (6)	1 (5)	1.00
Cancer follow-up	1 (6)	0	0.47
Other[a]	2 (11)	5 (26)	0.28
Thrombus location			
Portal vein	8 (47)	7 (36)	0.74
Superior mesenteric vein	2 (11)	5 (26)	0.41
Inferior mesenteric vein with extension	3 (18)	3 (17)	1.00
Multiple vessels	4 (24)	4 (21)	1.00
Splenic vein	0	0	N/A

[a] Follow-up for IBD, rule out post-operative abscess, nausea

($n = 10$), and other ($n = 49$). Six hundred and sixty-eight (55 %) of all procedures were completed laparoscopically, 75 (6 %) were converted to open, and 481 (39 %) were performed via an open approach. Mean length of surgery was 225 minutes (range, 32–905). Laparoscopic patients were all considered to have undergone extreme intraoperative positioning. Peak pneumoperitoneum pressures were based on surgeon preference and ranged from 13 to 15 mmHg. Intra-operative hypotension, defined as a mean arterial pressure (MAP) less than 65 mmHg or a systolic blood pressure (SBP) less than 100 mmHg, occurred in 638 patients (52 %). In the majority of these patients this was transient after induction. Intra-operative blood transfusion was administered to 119 patients (10 %). Post-operative hypotension (within 7 days of surgery) was identified in 583 patients (57 %). A total of 227 patients (19 %) required a blood transfusion in the post-operative period.

Post-operative radiologic assessment

A total of 385 patients (31 %) underwent CT imaging within 10 weeks of their operation to evaluate abdominal pain ($n = 166$), fever, leukocytosis, concern for anastomotic leak ($n = 85$) or bleeding ($n = 9$), cancer follow-up ($n = 26$), or multiple/other indications ($n = 99$). PMVT was diagnosed in 36 patients (3 %) by CT at a mean time of 14 days post-procedure (range, 3–69 days). Initial radiological assessment identified 17 of the 36 patients (1.4 %) with PMVT. Subsequent reanalysis of all post-operative CT images identified a further 19 patients (1.6 %) with PMVT. Indications for radiological imaging in these patients included all acute indications previously described, the most common being abdominal pain ($n = 14$). The majority of thrombi were located in the PV (42 %) or involved multiple splanchnic veins (22 %). Indications for performing abdominal imaging and location of thrombi were similar for both PMVT diagnosed at initial assessment and those found on review (Table 2).

Effect of clinical variables on PMVT

Patients with PMVT were significantly younger (53 vs. 62 years, $p = 0.001$) with higher BMI (30.5 vs. 26.7, $p < 0.001$) and maximum platelet levels (464 vs. 306, $p < 0.001$) compared to patients without PMVT. However, both patient groups were otherwise matched for clinical and surgical variables including cancer diagnosis (PMVT: 13/36 = 36 % vs. non-PMVT: 462/1,188 = 39 %, $p = 0.73$). Univariate logistic regression identified younger age ($p < 0.001$), obesity ($p < 0.001$), ulcerative colitis ($p < 0.001$), thrombocytosis, ($p < 0.001$) and restorative proctocolectomy ($p < 0.001$) as significant predictors of PMVT. Stepwise multivariate logistic regression identified that obesity ($p < 0.001$), thrombocytosis ($p < 0.001$) and restorative proctocolectomy with IPAA ($p = 0.001$) were still significant predictors. However, gender, smoking, history of thromboembolic events, hypercoagulable disorders, pre-operative antithrombotic treatment, indication for surgery, open or laparoscopic surgical approach and subsequent pneumoperitoneum pressure, peri-operative blood transfusion, and length of surgery were not significant predictors.

Patient outcome

No patients in the PMVT group suffered bowel infarction or required surgical intervention, and 30-day mortality was zero in the PMVT group. In patients found to have PMVT at time of presentation, 82 % were treated with therapeutic anticoagulation and nine underwent follow-up imaging which showed clot resolution in three patients. Mean time to follow-up was 107 days (range, 6–335) and mean time to clot resolution was 70 days (range, 19–120). Of all patients with PMVT, 19 (53 %) were readmitted within 30 days of discharge compared to 202 (17 %) of patients without PMVT ($p < 0.01$). In patients found on initial review to have PMVT, 10/17 were readmitted versus 9/19 of those whose PMVT was found on focused radiologic assessment ($p = 0.49$). Patients with PMVT, diagnosed either during the post-operative course or on review, were readmitted significantly more often than patients without

PMVT ($p < 0.01$ for both groups). Currently 1,043 patients are alive with mean follow-up of 43 months where 1/36 PMVT patients died and 180/1,188 non-PMVT patients died (3 % vs. 15 %, $p = 0.039$).

Discussion

The incidence of PMVT varies in the literature depending on the population evaluated. Although large series are few, the incidence of PMVT in the post-operative period appears to be low. The bariatric literature reports a PMVT incidence of 0.002–0.3 % following laparoscopic bariatric surgery [29, 30]. In the pediatric IBD population, the incidence of symptomatic thrombotic complications range from 1.3 to 2.3 % [4]. Cases of acute PV thrombosis following restorative proctocolectomy with IPAA for UC have been reported and in patients undergoing elective laparoscopic colorectal surgery with post-operative abdominal pain, an incidence of 3.5 % has been described [22, 24]. Consistent with existing literature, the incidence of PMVT in our study was low at 3 % of all patients undergoing major colon and rectal surgery. As a cohort, patients in this population possess nearly all of the presumed risk factors for PMVT: abdominal malignancy, IBD, obesity, and laparoscopic surgical approach. A low incidence in this population exemplifies the uncommon nature of the complication.

As compared to the non-PMVT group, patients with PMVT were younger. Age did not persist as a risk factor in multivariate regression analysis, but it is possible that younger patients are a marker for restorative proctocolectomy, which was a risk factor. Patients in the PMVT group had higher BMI comparatively, though averages in both groups were overweight. Obesity has recently been observed as an independent risk factor for PV thrombosis in the pre-transplant population, and in our study it remained the only modifiable risk factor associated with PMVT [21]. In this review, UC did not persist as an independent risk factor for PMVT. However, both IBD and obesity are associated with higher risk of peripheral DVTs [16, 31], and perhaps these hypercoagulable states can be extrapolated to abdominal DVTs. Therefore, physicians and colorectal surgeons performing pre-operative evaluations should counsel patients on the importance of reducing BMI prior to surgery. Patients with UC undergoing restorative proctocolectomy should be made aware of the risk of both lower extremity DVTs and PMVTs during the informed consent discussion. Consideration should especially be given to advise these patients to lose weight if their pre-operative BMI is above 30 kg/m^2.

In the general population, inherited thrombophilia is diagnosed in 33–75 % of patients with acute mesenteric venous thrombosis. However, this association may not translate to the post-operative patient population [28, 32]. Allaix et al. found 72.7 % of patients with PMVT after colorectal surgery had a prothrombotic abnormality. However, the authors concluded that extrinsic factors like active IBD, surgery, and sepsis combined with a hypercoagulable state lead to PMVT development and that congenital hypercoagulability could not be established as an independent risk factor [24]. In our study, there was no significant difference in prevalence of hypercoagulable disorders between the PMVT and non-PMVT groups and inherited thrombophilia was not a risk factor for PMVT development.

PMVT has been reported to have devastating effects on morbidity and mortality, and thus surgeons and physicians caring for patients in the post-operative period must be aware of high risk groups [28–30, 33]. Unplanned readmission rates were significantly higher in the PMVT group compared to the non-PMVT group. This was seen both in the group diagnosed on initial review and those diagnosed on focused radiologic assessment. Reasons for readmission included ileus, dehydration, wound infection, abdominal pain, PMVT or pulmonary embolism, and accidental dislodgment of an abdominal drain. In a recent retrospective review of 220 patients undergoing colon and rectal surgery at single institution, Kwaan et al. found PV thrombosis, PE, and BMI $\geq$ 30 kg/m^2 to be independent predictors of readmission within 60 days of discharge [34]. Other risk factors associated with readmission after colorectal operations include surgical site infection, stoma creation, hospital stay >7 days, and higher severity of illness [34]. Patients in the PMVT group had higher BMI, but otherwise similar clinical variables. In the PMVT group, the majority of patients were readmitted for reasons other than PMVT; however readmission after colon and rectal procedures should prompt consideration of the diagnosis.

In this study, patients with symptomatic PMVT diagnosed on initial imaging studies were treated with systemic anticoagulation and no patients required operative or endovascular intervention. There was no 30-day mortality associated with PMVT. An unexpected finding is that patients in the PMVT group had increased overall long-term survival compared with non-PMVT patients. Survival of patients with splanchnic vein thrombosis due to non-surgical causes (abdominal malignancy, cirrhosis, MPNs) has been evaluated, and in these populations increased predictors of mortality include older age and active cancer [33]. Though the PMVT and non-PMVT groups were matched for active cancer diagnosis, patients in the PMVT group were younger and more frequently underwent surgery for benign disease. This may have contributed to the increased overall survival demonstrated in the PMVT group. In patients without cancer or cirrhosis, the location

of thrombus may also be a predictor of infarction, an important factor of PMVT-associated mortality. In a retrospective review of 121 patients with PMVT, patients with isolated PV thrombosis were frequently asymptomatic and none developed intestinal infarction [35]. Contrastingly, patients with SMV thrombosis were often acutely symptomatic and intestinal infarction occurred in 45 % of cases. The review demonstrated that overall survival of patients with PMVT was 95 % at 1 year and 88 % of deaths occurred due to complications of intestinal infarction [35]. Conceivably, because intestinal infarction did not occur in any patient with PMVT in our study, overall survival was not impacted.

In total, 36 PMVTs were identified with abdominal CT; however, 19 PMVTs were diagnosed during retrospective focused assessment. Incidental radiologic findings are of increasing clinical relevance as imaging sensitivity improves and utilization increases. Though not widely studied, several reports have reviewed incidental or missed PMVTs in various populations. Ageno et al. performed a retrospective review of 2,591 abdominal CT scans not specifically requested for suspicion of abdominal DVTs in a general population of patients [36]. Forty-five scans (1.74 %) were positive for an incidental abdominal DVT, and specifically 1.17 % of surgical inpatients were discovered to have an incidental abdominal DVT on review. Of these retrospectively identified abdominal DVTs, 24 patients (53 %) in the study had symptoms of abdominal pain, nausea/vomiting, diarrhea, or fever at the time of imaging. Thus, these thrombi may have actually been missed as opposed to incidental findings identified during later review. Following restorative proctocolectomy with IPAA, Ball et al. reported a 39 % incidence of PV thrombosis found on retrospective review of all abdominal CT scans obtained within 8 weeks of surgery [37]. In our study, initial diagnostic imaging showed a PMVT rate of 1.4 % but after expert focused radiologic review the actual rate was 3 %, indicating the difficulty of diagnosis. Incidental or missed PMVTs found after initial review may be attributable to the subtle radiographic findings of venous thrombosis, especially for non-occlusive thrombi of smaller vessels. In the surgical population, post-operative stranding and edema may make prospective detection more difficult and thus influence the higher retrospective detection rates. Nevertheless, in high risk populations clinicians must be prudent to evaluate for PMVT.

As a result of these findings, the division of colorectal surgery's pre-operative informed consent discussion more frequently includes both peripheral and abdominal DVTs, and the necessity of pre-operative weight loss for obese patients is further advocated. Identifying higher risk groups for PMVT development has heightened awareness of the complication for surgeons and diagnostic imagers at our institution. It has also lowered the threshold to consider the diagnosis of PMVT in colorectal patients with abdominal pain in the post-operative period.

In this cohort, several patients with PMVT were diagnosed while on DVT chemoprophylaxis. Therefore, the role of extending anticoagulation beyond the hospital stay is unclear at this point. Though the risk of extending prophylaxis is relatively low, the cost to patients and inconvenience of dosing these medications may be a barrier. To date, post-operative mechanical and chemoprophylaxis remains standard of care while hospitalized, however institutional guidelines regarding extending treatment beyond discharge have not been standardized.

The major limitation of this study is the retrospective design. Patients underwent a wide range of colorectal procedures by multiple surgeons including fellowship trained colorectal surgeons, general surgeons, and gynecologic surgical oncologists. This allowed for broader analysis; however it also accounts for variation in perioperative care. Perioperative DVT chemoprophylaxis was not standard among all patients. In some cases this was due to increased risk of bleeding in surgery performed urgently for refractory gastrointestinal hemorrhage. Surgeon preference was another reason for not administering perioperative chemoprophylaxis, especially in the gynecologic surgery patients. Standardized follow-up with repeat imaging of all patients in the PMVT group, both for treated and untreated patients, would have allowed for further analysis of missed PMVT sequelae and efficacy of anticoagulation therapy on clot resolution.

Conclusion

The incidence of PMVT following colon and rectal surgery is nearly 3 %, and up to 50 % are missed at the time of initial imaging due to the difficulty in diagnosis. Risk factors for PMVT identified with univariate analysis include younger patient age, obesity, and ulcerative colitis, in addition to post-operative thrombocytosis and restorative proctocolectomy procedures. Laparoscopic approaches are not associated with a higher risk. Multivariate analysis identified obesity, post-operative thrombocytosis, and restorative proctocolectomy as independent predictors for PMVT after colorectal surgery. Readmission after a colorectal procedure should prompt consideration of PMVT, especially if abdominal pain is a significant feature and any of the above risk factors are present. Though higher 30-day unplanned readmission rates were associated with PMVT, overall long-term survival was unexpectedly higher. Further studies are needed to evaluate this finding.

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