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Clinical and ultrasound features of pseudomyxoma peritonei and its histopathological subtypes among women seen at a Philippine tertiary hospital: A 10-year review

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Abstract:

OBJECTIVES: Pseudomyxoma peritonei (PMP) in women arises from an appendiceal or ovarian pathology and presents either of two histological subtypes of differing prognosis, disseminated peritoneal adenomucinosis (DPAM), or peritoneal mucinous carcinomatosis (PMCA). This study aimed to evaluate the demographic, clinical, and sonographic features among affected women and the differences between the two histological subtypes.

METHODS: A retrospective study was conducted involving 36 women with histopathological diagnosis of PMP who had preoperative ultrasound and underwent surgery at the department of obstetrics and gynecology in a tertiary hospital. Demographic and clinical data, ultrasound images and reports, and final histopathology were reviewed. To compare the subtypes, one-way analysis of variance for continuous data and Chi-square/Fisher exact test for categorical data were used, with $P < 0.05$ indicating statistical significance.

RESULTS: Patients were mostly >50 years of age, multigravid, and presented with abdominal distention. Ultrasound examinations consistently showed amorphous, mixed echo or echogenic ascites, peritoneal thickening, and omental caking. Adnexal/ovarian masses were detected in 66.7% of cases. Omental caking was significantly more prevalent in PMCA (83.3%; $P = 0.0002$), whereas larger ovarian tumors (>20 cm) and papillarities were more common in DPAM (both 92.9%; $P = 0.0005$). Most patients underwent gynecologic surgery ($n = 31$; 86.1%), and 14 (38.9%) required readmission due to recurrence. The final histopathology revealed largest tumor involvement of the appendix ($n = 13$; 36.1%), the ovaries ($n = 11$; 30.5%), or undetermined ($n = 12$; 33.3%).

CONCLUSIONS: Preoperative diagnosis of PMP is possible based on its clinical and ultrasound features. Although the subtypes are similar in most of these features, certain ultrasound findings may aid in distinguishing them.

Keywords:

Disseminated peritoneal adenomucinosis, ovarian mucinous cystadenoma, peritoneal mucinous carcinomatosis, pseudomyxoma peritonei, ultrasound

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Introduction

Pseudomyxoma peritonei (PMP) is a disease characterized by the presence of mucin in the peritoneal cavity. While the most common cause is appendiceal cancer, several types of tumors (including noncancerous tumors) can cause the disease. It is an uncommon clinical entity, with an estimated annual incidence of 1–2 per million.[1-3] More women are affected, involving 50%–64% of cases and

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often have synchronous ovarian and appendiceal tumors.[4] The determination of the primary site of origin in women is further complicated by the well-known occurrence of secondary involvement of the ovaries by mucinous carcinomas of gastrointestinal origin, which simulate primary ovarian tumors, both clinically and histologically.[5]

PMP is divided into two histologic and diagnostic categories: (1) Disseminated peritoneal adenomucinosis (DPAM), which is a relatively indolent disease, comprising borderline malignant epithelial cells derived from a well-differentiated, low-grade mucinous tumor and involving most likely the appendix and (2) peritoneal mucinous carcinomatosis (PMCA), which is more aggressive and infiltrative, comprising poorly differentiated cells that produce copious amounts of extracellular mucin, more commonly with extra-appendiceal involvement, including the ovaries.[2,6-8]

The cases of PMP classically present with slow abdominal distention accompanied by vague abdominal symptoms of pain and discomfort resulting from the accumulation of mucin. Women may complain of palpable abdominal masses due to the presence of omental caking or rapidly enlarging ovarian masses.[9] Further progression leads to malnutrition, bowel obstruction, and respiratory compromise. Computed tomography (CT) scan is the imaging modality of choice[10,11] and has been reported to be the most common mode of diagnosis, often revealing the omental caking and mucinous ascites.[12] The classical CT imaging feature however is scalloping of the liver surface, which is indentation of the liver capsule by tumor deposits, differentiating it from serous ascites.[9] In contrast, magnetic resonance imaging (MRI) may be helpful in assessing involvement of the small bowel, the hepatoduodenal ligament[13-15] and other peritoneal metastases.[16] While the characteristic features on CT scan and MRI are well-established, both are not routinely requested in the local setting for practical reasons. The cost, applicability, and availability of US make it a better and preferred alternative. Patients may be managed by the general surgery services, but women are likely referred to gynecology and ultrasound services to rule out gynecologic pathology and for preoperative imaging, respectively. There are mostly case reports and few published reviews that center on the clinical features and less so on the ultrasound findings of ovarian masses associated with PMP.[17-21] This study aimed to review the demographic, clinical (including surgical and intraoperative findings), and ultrasound features among women with histopathologic diagnosis of PMP. Since the two histologic types have distinct clinical presentation and prognosis, this study will also evaluate if they can be distinguished based on these features. It also aimed to identify specific ultrasound parameters including the characteristics of the ovarian masses and concurrent findings, which are significant findings uniquely seen among affected women. Imaging is frequently the first step in its diagnosis and management, with a significant impact on the preoperative preparation and prognosis of the disease. Correctly diagnosing or early recognition of PMP and its subtypes among women are essential, so that proper referral and management by appropriate specialists can be made. This is to ensure that those with involvement of ovarian masses will be referred to a gynecologist and/or a gynecologic oncologist. To our knowledge, this is the first institutional and local review of cases managed by the gynecology service and with preoperative ultrasound assessment.

Methods

Study design

This is a retrospective study of PMP cases admitted at the Department of Obstetrics and Gynecology of the University of the Philippines (UP), Philippine General Hospital. The UP-Manila Research Ethics Board approved the study protocol.

Study population

The study included all patients who underwent surgery at the department of obstetrics and gynecology from August 2009 to July 2019 with preoperative ultrasound evaluation at the Division of Ultrasound and with final histopathologic diagnosis of PMP. Excluded were those cases who had no patient record, without ultrasound results and images/videos at the Division of Ultrasound, or those who had surgery conducted in the department of surgery or in other institutions. The minimum required sample size is 31 patients computed based on its 1%–2% worldwide incidence and with assumptions of 95% confidence level and 5% precision.

Conduct of the study

There were 36 patients identified and included in the study based on the histopathologic results retrieved from the surgicopathologic census of the department and from the census of the division of gynecologic oncology. The histopathologic examination of the slides was performed and signed out by different pathologists. The demographic information and clinical data were obtained from the patient charts and recorded. Ultrasound results and images of these patients were retrieved and reviewed together by the two sonologists-authors/investigators. Based on still images and video clips, the following sonographic features were re-evaluated and described according to the International Ovarian Tumor Analysis terms and descriptions of adnexal masses and other findings when applicable:[22] Presence and echogenicity of ascites, peritoneal masses/thickening, omental caking,

enlarged lymph nodes, and the presence, size, and appearance of pelvic/adnexal masses. The ultrasound features of the masses were described in terms of number of locules, presence of papillations, diameter of mass/lesion, laterality, echogenicity, and color score, and final ultrasound impression.

Statistical analysis

All the data were encoded and analyzed using the MedCalc Statistical Software version 19.2.6 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2020). Descriptive statistics were used for the categorical data variables, expressed as frequency and percentage. Normally distributed continuous variables were expressed as mean and standard deviation. The two histologic grades were compared based on the ultrasound features using *F* test through the one-way analysis of variance for continuous data and Chi-square/Fisher exact test for categorical data. The level of significance for all sets of analysis was set at $P < 0.05$.

Results

Demographic and clinical features

A total of 36 patients were included in the study, of which 24 (66.7%) were DPAM and 12 (33.3%) were PMCA on final histopathology. Most patients were aged 50–59 years ($n = 14$; 38.9%), multigravida, and with abdominal distention as the most common presenting symptom ($n = 18$; 50%). The majority of the cases had an admitting clinical impression of malignant ovarian new growth ($n = 27$; 75%). The average length of hospital stay was ≥7 days ($n = 33$; 91.7%) and less than half of the cases ($n = 14$; 38.9%) were re-admitted due to recurrence of abdominal distention. Postsurgery, most of the patients were monitored and seen for chemotherapy ($n = 29$; 80.6%), while 19.4% ($n = 7$) had no record of follow-up at the out-patient clinic. There were no significant differences in the demographic and clinical features between the two histologic types of PMP [Table 1].

Preoperative ultrasound findings

The ultrasound impression prior to surgery was more commonly "ovarian new growth probably malignant" ($n = 14$; 38.9%), but the rest had a straightforward impression of "PMP with or without a concomitant finding of ovarian new growth" [$n = 22$; 61.1%, Table 2]. Ascites was seen in most cases [$n = 33$; 91.7%, Figure 1], seen as amorphous echogenic or mixed echo ascitic fluid ($n = 13$; 36.1%), or may be septated ($n = 10$; 27.8%), and displacing the bowel loops away from the anterior abdominal wall, or may appear anechoic ($n = 10$; 27.8%) and less commonly with no ascitic fluid ($n = 3$; 8.3%).

Peritoneal masses or peritoneal thickening were noted on ultrasound in 52.5% ($n = 19$). Omental caking [Figure 2] was significantly more common among PMCA ($n = 10$; 83.3%) than DPAM ($n = 4$; 16.7%). The lymph nodes were reported to be difficult to evaluate in both histologic types (66.7%–83.3%). Adnexal or abdominopelvic mass was detected only in some cases of both DPAM and PMCA types ($n = 14$; 58.3% vs. $n = 10$; 83.3%, respectively). The adnexal/abdominopelvic masses detected on ultrasound were mostly multiloculated with mixed echoes within [Figure 3 and Table 3].

Apart from omental caking, the diameter of adnexal lesions was significantly different between the 2 histologic types based on the ultrasound parameters evaluated, with 92.9% ($n = 13$) of DPAM presenting as larger masses more than 20 cm in diameter, although PMCA likewise presented with huge masses albeit relatively smaller (15–20 cm in 7 or 70% of cases) than what was commonly seen with DPAM. Similarly, the presence of papillarities within the adnexal or ovarian masses was significantly more common in cases with DPAM than in PMCA [Table 3]. On Doppler studies, although statistically insignificant, DPAM mostly exhibited minimal flow ($n = 10$; 71.4%), while PMCA had moderate vascular flow ($n = 6$; 66.7%).

Surgery and intraoperative findings

All patients underwent exploratory laparotomy and the average blood loss incurred during surgery was 816.7 mL. Among these patients, 31 (86.1%) underwent major gynecologic pelvic surgery, while 5 (13.9%) underwent only biopsy of masses or implants and not tumor debulking due to extensive adhesions [Table 4]. Most cases underwent additional surgical procedures including appendectomy ($n = 19$; 61.3%) performed by the general surgery service and proceeded to cytoreductive surgery (CRS) ($n = 1$; 3.2%) with hypothermic or heated intraperitoneal chemotherapy (HIPEC, $n = 3$; 9.7%).

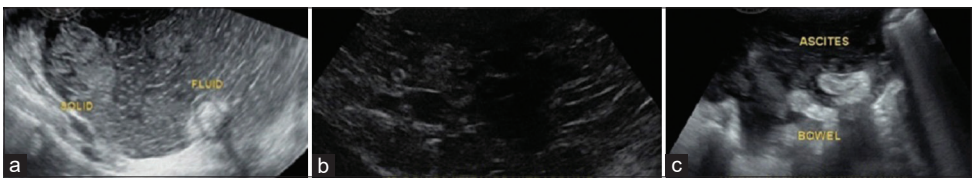

Figure 1: Sonologic features of ascites in pseudomyxoma peritonei, seen as mixed echo fluid, described as amorphous or jelly-like on probe manipulation with no septations noted (a) or may appear with prominent septations (b). Bowel loops are displaced from the anterior wall by mixed echo ascitic fluid (c)

Table 1: Demographic and clinical profile of women with histopathological diagnosis of disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei

	Total cases (*n*=36), *n* (%)	Mean±SD	DPAM (*n*=24), *n* (%)	PMCA (*n*=12), *n* (%)	*P*
Age					
<30	0	54.3±10.3	0	0	0.7454
30–39	3 (8.3)		2 (8.3)	1 (8.3)	
40–49	8 (22.2)		5 (20.8)	3 (25.0)	
50–59	14 (38.9)		11 (45.8)	3 (25.0)	
60–69	7 (19.4)		5 (20.8)	2 (16.7)	
70–79	4 (11.1)		1 (4.2)	3 (25.0)	
Gravidity					
0	1 (2.8)	3.6±2.5	1 (4.2)	0	0.6024
1	7 (19.4)		6 (25.0)	1 (8.3)	
2	6 (16.7)		4 (16.7)	2 (16.7)	
3	7 (19.4)		4 (16.7)	3 (25.0)	
4	5 (13.9)		3 (12.5)	2 (16.7)	
>5	10 (27.8)		6 (25.0)	4 (33.3)	
Parity					
0	1 (2.8)	3.2±2.3	1 (4.2)	0	0.3106
1	9 (25.0)		8 (33.3)	1 (8.3)	
2	7 (19.4)		4 (16.7)	3 (25.0)	
3	6 (16.7)		4 (16.7)	2 (16.7)	
4	3 (8.3)		1 (4.2)	2 (16.7)	
>5	10 (27.8)		6 (25.0)	4 (33.3)	
Weight (kg), mean±SD	---	57.9±10.8	56.6±9.1	60.4±13.6	0.3255
Chief complaint					
Vaginal bleeding	1 (2.7)		0	1 (8.3)	0.6755
Amenorrhea	0		0	0	
Abdominal mass	9 (25.0)		6 (25.0)	3 (25.0)	
Abdominal distension	18 (50.0)		12 (50.0)	6 (50.0)	
Abdominal pain	7 (19.4)		5 (20.8)	2 (16.7)	
Others	1 (2.7)		1 (4.2)	0	
Initial clinical working diagnosis					
Ovarian new growth, probably malignant	27 (75.0)		18 (75.0)	9 (75.0)	1.0000
Pseudomyxoma Peritonei, rule out gynecologic pathology	9 (25.0)		6 (25.0)	3 (25.0)	
Length of hospital stay (days)					
3	1 (2.8)	16.7±10.6	1 (4.2)	0	1.000
4–6	2 (5.6)		1 (4.2)	1 (8.3)	
≥7	33 (91.7)		22 (91.7)	11 (91.7)	
Reason for re-admission					
Readmitted for recurrence of abdominal distention	14 (38.9)		8 (33.3)	6 (50.0)	0.3509
Other medical/surgical reason	7 (19.4)		4 (16.7)	3 (25.0)	
Not readmitted	15 (41.7)		12 (50.0)	3 (25.0)	
Outpatient follow-up					
Monitoring/chemotherapy	29 (80.6)		21 (87.5)	8 (66.7)	0.2603
No record of follow-up	7 (19.4)		3 (12.5)	4 (33.3)	

DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis, SD: Standard deviation

On evaluation of the largest tumor diameter involved [Table 5], there was almost equal distribution among the ovary (n = 11; 30.5%), the appendix (n = 13; 36.1%), and undetermined organ (involving both appendix and ovaries, n = 12; 33.3%). While the ovaries and appendix were equally involved in DPAM (both 33.3%), the ovary was least involved with PMCA (16.7%), but these findings were not significantly different (P = 0.084). The majority of the ovarian tumors were mucinous borderline tumors (n = 8; 88.9%). Among those who underwent gynecologic pelvic surgery, 11 (35.5%) of them were referred to gynecologic oncology service and underwent surgical staging for ovarian cancer, with the majority of them in stage 1C (n = 6; 19.4%). However, in most of the cases (n = 20; 64.5%), limited surgical procedure precluded assignment to a surgical stage [Table 6].

Table 2: Ultrasound findings among women with disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei

Ultrasound features	Total cases (*n*=36), *n* (%)	DPAM (*n*=24), *n* (%)	PMCA (*n*=12), *n* (%)	*P*
Preoperative ultrasound impression				
Ovarian new growth, probably malignant	14 (38.9)	12 (50.0)	2 (16.7)	0.0991
Pseudomyxoma peritonei	12 (33.3)	10 (41.7)	2 (16.7)	
Ovarian new growth, probably malignant with pseudomyxoma peritonei	10 (27.8)	2 (8.3)	8 (66.7)	
Presence of ascites				
Echogenic/mixed echo*	13 (36.1)	11 (45.8)	2 (16.7)	0.621
Septated	10 (27.8)	4 (16.7)	6 (50.0)	
Anechoic	10 (27.8)	8 (33.3)	2 (16.7)	
No ascites/free fluid	3 (8.3)	1 (4.2)	2 (16.7)	
Peritoneal mass				
Peritoneal masses/thickening	19 (52.8)	11 (45.8)	8 (66.7)	0.3020
None seen/unremarkable	17 (47.2)	13 (54.2)	4 (33.3)	
Omental caking				
Omental caking	14 (38.9)	4 (16.7)	10 (83.3)	0.0002 (S)
None seen/unremarkable	22 (61.1)	20 (83.3)	2 (16.7)	
Presence of lymph nodes				
Positive	1 (2.8)	1 (4.2)	0	0.6330
No lymphadenopathies seen	9 (25.0)	7 (29.2)	2 (16.7)	
Nodes difficult to assess	26 (72.2)	16 (66.7)	10 (83.3)	
Adnexal mass				
Presence of adnexal or pelvic mass	24 (66.7)	14 (58.3)	10 (83.3)	0.2603
No adnexal/pelvic mass seen	12 (33.3)	10 (41.7)	2 (16.7)	

*Amorphous echogenic or mixed echo ascitic fluid. S: Significant, DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis

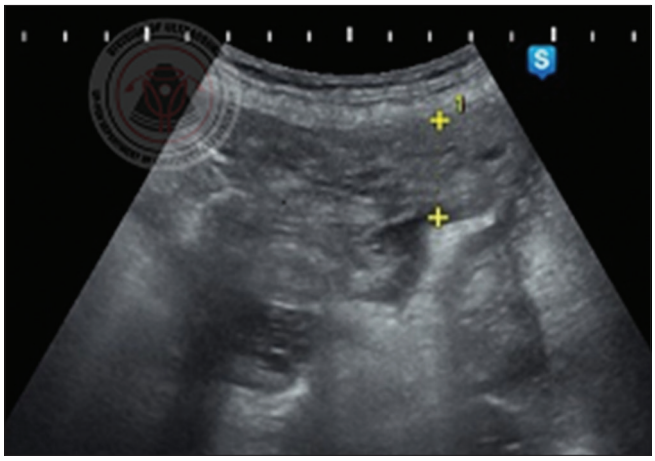

Figure 2: Omental thickening and caking are seen on ultrasound among cases with pseudomyxoma peritonei, significantly more common in peritoneal mucinous carcinomatosis type

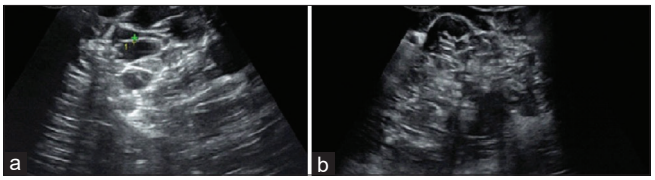

Figure 3: Adnexal and ovarian masses seen in pseudomyxoma peritonei. Sonologic findings of adnexal masses found in disseminated peritoneal adenomucinosis type (a) and peritoneal mucinous carcinomatosis type (b), both showing multilocular cysts with mixed echoes within representing mucinous debris

Discussion

Detection and assessment of PMP can be done preoperatively based on clinical presentation and concurrent specific ultrasound findings. The disease is characterized by slow and progressive accumulation of mucin in the peritoneal cavity resulting in typical presentation of massive symptomatic distention and associated mechanical and functional gastrointestinal obstruction.[23] This explains the most common presenting symptom of abdominal distension/enlargement among the patients included in this study. Similar to the demographic profiles in previously published reports on PMP, the cases reported here involved multigravida and older women >50 years of age.[5,24]

Imaging in pseudomyxoma peritonei

The availability of ultrasound, CT scan, and MRI has now made possible the noninvasive preoperative diagnosis of PMP. Compared with CT scan, MRI could show mucous groups, fibrous septa, and ovarian primary tumors more clearly.[25] Ultrasound has limitations in determining an accurate extent of tumors in some small bowel regions. However in the abdominopelvic region, a more accurate extent can be obtained by ultrasound than CT scan.[3] Comparing MRI and ultrasound, the latter is simple and relatively inexpensive and hence is readily available for use in evaluating patients in our institution. Women with clinical impression of abdominopelvic mass are most often referred to the department and its ultrasound

Table 3: Sonographic findings of ovarian/pelvic masses among women with disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei

Ultrasound features of adnexal mass	Total cases (*n*=24), *n* (%)	DPAM (*n*=14), *n* (%)	PMCA (*n*=10), *n* (%)	*P*
Locularity				
Unilocular	0	0	0	1.000
Unilocular-solid	0	0	0	
Multilocular	16 (66.7)	9 (64.3)	7 (70.0)	
Multilocular-solid	8 (33.3)	5 (35.7)	3 (30.0)	
Solid	0	0	0	
Number of locules				
5–10	1 (4.2)	1 (7.1)	0	1.000
>10	23 (95.8)	13 (92.9)	10 (100)	
Papillarities				
Present	15 (62.5)	13 (92.9)	2 (20)	0.0005 (S)
Absent	9 (37.5)	1 (7.1)	8 (80)	
Largest diameter of the lesion (cm)				
10–15	1 (4.2)	0	1 (10)	0.0005 (S)
15–20	8 (33.3)	1 (7.1)	7 (70)	
>20	15 (62.5)	13 (92.9)	2 (20)	
Laterality of mass on ultrasound				
Right	5 (20.8)	4 (28.6)	1 (10)	0.3577
Left	0	0	0	
Undetermined	19 (79.2)	10 (71.4)	9 (90)	
Echogenicity of the cyst content				
Anechoic	0	0	0	0.2825
Low	3 (12.5)	3 (21.4)	0	
Medium	5 (20.8)	3 (21.4)	2 (20.0)	
Mixed	15 (62.5)	7 (50.0)	8 (80.0)	
High	1 (4.2)	1 (7.1)	0	
Color score on doppler studies				
No flow	0	0	0	0.2112
Minimal flow	14 (58.3)	10 (71.4)	4 (33.3)	
Moderate flow	10 (41.7)	4 (28.6)	6 (66.7)	
Abundant flow	0	0	0	

S: Significant, DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis

Table 4: Surgical procedures performed on women with histopathologic diagnosis of disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei

	Total cases (*n*=36), *n* (%)	DPAM (*n*=24), *n* (%)	PMCA (*n*=12), *n* (%)	*P*
Gynecologic procedures				
Biopsy of implants and masses from multiple organs involved	5 (13.9)	3 (12.5)	2 (16.7)	0.3293
THBSO	31 (86.1)	21 (87.5)	10 (83.3)	
Additional surgical procedures done (n=31)				
Surgical staging for ONG (PFC, BLND, PALS, IO, PFC)	3 (9.7)	2 (9.5)	1 (9.0)	
Appendectomy only	19 (61.3)	14 (66.7)	5 (50.0)	
Tumor debulking	5 (16.1)	4 (19.0)	1 (10.0)	
CRS	1 (3.2)	0	1 (10.0)	
CRS + HIPEC	3 (9.7)	1 (4.8)	2 (20.0)	

DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis, ONG: Ovarian new growth, CRS: Cytoreductive surgery, HIPEC: Hyperthermic intraperitoneal chemotherapy, THBSO: Total hysterectomy with bilateral salpingo-oophorectomy, PFC: Peritoneal fluid cytology, BLND: Bilateral pelvic lymph node dissection, PALS: Para-aortic lymph node sampling, IO: Infracolic omentectomy

unit for preoperative scans and to rule out gynecologic pathology.

The detection rate of ultrasound for PMP lesions is high, accurately identifying sonologic features such as omental caking, ascites, and bowel loop adhesion, but cannot discriminate from other peritoneal lesions which include tuberculous peritonitis, peritoneal metastatic carcinomatosis, and malignant mesothelioma.[1] The overall sensitivity has been reported to be 85.7%–91.5% but has low specificity at 33.8%–50.0%.[3,26] The presence of highly echogenic ascitic fluid is the most consistent

Table 5: Predominant organ involved (tumor with greatest diameter) based on histopathologic findings among women with disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei

	Total cases (*n*=36), *n* (%)	DPAM (*n*=24), *n* (%)	PMCA (*n*=12), *n* (%)	*P*
Ovary	11 (30.5)	9 (37.5)	2 (16.7)	0.0842
Borderline mucinous tumor	8 (22.2)	8 (33.3)	0	
Mucinous cystadenoma	3 (8.3)	1 (4.2)	2 (16.7)	
Appendiceal tumor	13 (36.1)	8 (33.3)	5 (41.7)	
Involving both appendix and ovaries (undetermined)	12 (33.3)	7 (29.2)	5 (41.7)	

DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis

Table 6: Surgical staging for ovarian cancer among women with disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis types of pseudomyxoma peritonei who underwent gynecologic surgery

	Total cases (*n*=31), *n* (%)	DPAM (*n*=21), *n* (%)	PMCA (*n*=10), *n* (%)	*P*
With surgical staging	11 (35.5)	5 (23.8)	6 (60.0)	0.1055
IA	-	-	-	
IB	-	-	-	
IC	6	3	3	
IIA	-	-	-	
IIB	-	-	-	
IIIA	-	-	-	
IIIB	1	1	-	
IIIC	4	1	3	
IVA	-	-	-	
IVB	-	-	-	
No surgical staging	20 (64.5)	16 (76.2)	4 (40.0)	

DPAM: Disseminated peritoneal adenomucinosis, PMCA: Peritoneal mucinous carcinomatosis

ultrasound finding.[5] A good number of the cases seen in this review were given an outright ultrasound impression of PMP based on pattern recognition alone. In published studies, highly echogenic ascites is the most common sonologic feature and this was also seen in our study with the fluid described as amorphous, echogenic, or mixed echo fluid. The echogenic foci are immobile when there is a change in patient position or transducer pressure, differentiating it from those that result from bloody or fibrinous exudates.[6] Ascites could be confusing when seen in PMP. With benign ascites, the bowel floats freely to the anterior abdominal wall and shifts with position. In PMP, the gelatinous ascites is fixed and separates the bowel from the anterior abdominal wall.[27]

Peritoneal masses or thickening and omental caking were common ultrasound findings among the patients in this current study. In a published report involving 19 cases of PMP, both these findings were consistently observed in all cases. At low frequency, the echogenicity of the thickened peritoneum was described as heterogeneous while the omentum was remarkedly thickened, measuring 0.4 cm–6.0 cm. At high frequency there were tiny anechoic cysts noted within the omentum.[1] Several studies suggest that the increased echogenicity of an omental cake is attributed to the presence of these numerous tiny cysts.[2,28] These findings were not among those specific features described in this study, as the retrospective nature precluded its evaluation. Interestingly, however, our study found a significantly higher occurrence of omental caking in the PMCA histologic subtype, suggesting its association with this particular subtype. Conversely, the absence of omental caking may indicate a likelihood of the DPAM histologic subtype. While these findings differ from previously published data which noted that both histologic types tend to exhibit thickened omentum with anechoic areas of varying sizes,[1,29] another study showed that the lack of an omental caking suggested the diagnosis of DPAM, consistent with the results of our study.[2]

No significant differences were found in the other sonographic features when comparing the two histologic subtypes. In terms of the characteristics of the ascitic fluid, both displayed prominence of amorphous echogenic/mixed echo type of fluid, which we consider as ultrasound markers of PMP together with peritoneal thickening and omental caking, more so in the presence of huge loculated abdominopelvic masses typically seen with ovarian mucinous cystadenoma or borderline mucinous tumors, which were the final histopathologic reports of the cases included in this study. It is therefore not surprising that the other ultrasound features of the adnexal masses were consistent with mucin containing cysts, specifically mixed echo fluid or debris that in the hands of less astute sonologists may be described as solid contents. There are few published reviews or case reports on the ultrasound features of ovarian masses associated with PMP, but nevertheless, they were described as irregular,

multiloculated, enlarged, and containing mucinous material on ultrasound.[17] Interestingly, it appears to be that papillarities are significantly more common in the adnexal masses seen with DMPA. Similarly, adnexal masses found in DPAM have a significantly greater diameter (usually >20 cm) as compared to the relatively smaller albeit still large cysts (at 15–20 cm) found in PMCA. However, the cases with ovarian masses seen in this review were all in chronically and advanced stage for both DPAM and PMCA and hence were likely to present with huge masses. It would be interesting to know if this significant size difference can be observed during the early stage of the disease. Nevertheless, the presence of these large masses concurrent with the echogenic ascitic fluid precluded preoperative ultrasound evaluation of the pelvic and para-aortic lymph nodes for most of the cases.

Surgery and intraoperative findings

There are different proposed management protocols for PMP, and most would advocate surgical debulking. The current standard with reported 5-year survival rate of approximately 90% in the most favorable prognostic group of patients, is complete CRS combined with heated intraperitoneal chemotherapy (HIPEC) with mitomycin-c.[30] Hyperthermia has been shown to potentiate chemotherapy penetration.[24,31] All of the patients in this current study underwent laparotomy and the majority had gynecologic surgery. Additional surgical procedures such as appendectomy, tumor debulking, and CRS were also conducted, while only a few cases had hyperthermic intraperitoneal chemotherapy. While some of the cases included in the study were able to follow-up for chemotherapy, it is unfortunate that some were lost to follow-up, either postoperatively or while ongoing chemotherapy; hence, an evaluation of the survival rate cannot be inferred from the current data.

The most frequent cause of PMP originating from a primary ovarian tumor is the ruptured mucinous tumors arising from an ovarian pathology.[2,5,32] Dissemination is usually localized in one region, but it may spread to multiple sites. A good washing of the peritoneal cavity is useful during surgery, but recurrence may still occur. Even after surgery or tumor debulking, the increasing mucous accumulation from a retained tumor implantation may slowly lead to recurrence of symptoms. In general, recurrences occur in 20%–30% of patients even after CRS with HIPEC.[4] In this study, a higher percentage of the patients (38.9%) were re-admitted due to recurrence of abdominal distention likely due to the intrinsic nature of the disease but probably confounded by the patient's noncompliance in follow-up and management.

The final histopathologic results in this study reported the appendix as the organ more commonly involved based on the largest tumor diameter by histopathological evaluation, albeit with small insignificant difference only (36.1% vs. 30.5% involving the ovary). In the remaining third of the cases (33.3%), the largest organ involved could not be determined. While immunohistochemistry techniques are important in identifying the primary organ involved, these were not routinely performed in the cases seen in our institution. Nevertheless, the preponderance of the appendiceal involvement as reported in the final histopathologic findings supported the theory of other published studies that pseudomyxoma peritonei may primarily be of appendiceal origin.[1,3,25] More recent evidence suggests that any ovarian tumors present are usually the result of a secondary spread from ruptured appendiceal lesion, like a simple mucocele, an appendiceal hyperplasia or an appendiceal adenocarcinoma.[27] This suggestion is also supported by the fact that ovarian lesions involved are often right sided or bilateral on ultrasound and intra-operative findings.[2] However, despite this prevailing belief that PMP originates from the appendix, evaluation for the presence of ovarian masses should still be routinely performed using any imaging technique, as they can be a potential source of mucinous tumors.

Summary and Conclusions

Preoperative diagnosis of PMP is possible based on its clinical and ultrasound features. Affected women characteristically have slow abdominal distention that predominantly involve older (>50 year old) and multigravid patients. Imaging when correlated with these clinical features plays a crucial role in recognizing and diagnosing PMP, enabling appropriate referral and management by specialists. Ultrasound findings, such as the presence of amorphous, echogenic or mixed echo ascitic fluid, peritoneal thickening, and omental caking, raise suspicion of PMP. While the prevailing belief is that PMP originates from the appendix, the presence of ovarian masses on ultrasound should also be evaluated, as they can be a potential source of mucinous tumors.

Differentiating between the two histologic subtypes of PMP based on clinical presentation is challenging. However, ultrasound findings such as omental caking favor a diagnosis of PMP with appendiceal origin (PMCA), whereas the presence of papillarities and a relatively larger ovarian or adnexal mass exceeding 20 cm suggests the DPAM subtype. Despite the difficulty in distinguishing between the two subtypes, ultrasound remains a reliable diagnostic tool for establishing a preoperative diagnosis of PMP.

Limitations and recommendations

This study has certain limitations that should be acknowledged. First, it does not include cases of PMP in women that were admitted under the general surgery service without a gynecologic referral and without

preoperative ultrasound conducted in the Division of Ultrasound. Similarly, this study was conducted in a tertiary referral center with most cases in their advanced stages of the disease, and with no immunohistopathological evaluation performed to determine the tissue of origin. Finally, since this is a retrospective study, it was not possible to extract the complete clinical course for all cases based on the medical records, and hence, details regarding the progression and outcomes of the patients were not included in this review. These limitations emphasize the need for multicenter and prospective studies that can provide comprehensive data on the early presentation and clinical course of PMP.

Authorship contributions

Melissa D. Amosco, MD and Toni Andrea Marie D. Viloria MD - Contributed to the conceptualization and design of the study, formal analysis, and writing of the draft and final paper.

Toni Andrea Marie D. Viloria MD - Investigation (data collection, review of ultrasound images) and data curation.

Melissa D. Amosco, MD - Investigation (review of ultrasound images), review, editing, and visualization of final work.

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Conflicts of interest

There are no conflicts of interest.

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