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Non-invasive diagnostic imaging of Pelvic Venous Disorders.

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Abstract:
It is estimated that the problem of Chronic Pelvic Pain (CPP) may concern up to 24% of women. Unfortunately, very often, despite extensive diagnostics, the cause of CPP remains unknown. The pathophysiology of CPP could be explained to a large extent by the occurrence of Pelvic Venous Disorders (PVD). Although pelvic venography is still considered the gold standard for the diagnosis of PVD, non-invasive diagnostic imaging techniques seem to be instrumental in the initial identification of patients with PVD.
This literature review aimed to analyse and evaluate the usefulness of non-invasive diagnostic imaging techniques like Transvaginal Ultrasonography, Transabdominal Ultrasonography, Magnetic Resonance and Computed Tomography in the diagnosis and identification of patients with PVD.
Forty-one articles published between 1984 and 2023 were included in this literature review.
Based on this literature review, we conclude that the clinical application of non-invasive diagnostic techniques in the diagnosis of PVD seems to be very promising.
Future studies investigating the role of non-invasive diagnostic imaging techniques in the diagnosis of PVD are required.

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Introduction

According to the Royal College of Obstetricians and Gynaecologists, Chronic Pelvic Pain (CPP) can be defined as a condition in which intermittent or constant pain (dull ache or fullness) in the lower abdomen or pelvis lasts at least six months, and the occurrence of pain is not related to pregnancy, sexual intercourse, or menstrual cycle [1]. However, pain could be aggravated by menstruation, sexual intercourse, pregnancy, prolonged standing, or overexertion. Other non-specific symptoms could include vulvar swelling, vaginal discharge, urinary urgency, rectal discomfort, back pain, hip pain, varicose veins of the vulva, perineum and lower extremity, persistent genital arousal disorder, flatulence, nausea, headache, apathy, and depression [2–4].
It is estimated that the problem of CPP may concern up to 24% of women [5,6]. CPP differential diagnosis should consider gynaecological, gastrointestinal, urological, neurological, musculoskeletal, and mental health disorders. Unfortunately, very often, despite extensive diagnostics, the cause of CPP remains unknown [7–10]. The pathophysiology of CPP can be explained to a large extent by the occurrence of Pelvic Venous Disorders (PVD) [4,11]. PVD enclose a group of disease entities whose common feature is the occurrence of the listed above symptoms of CPP, and varices localized in the pelvis and abdomen. The nomenclature update has changed historically used terms such as pelvic congestion syndrome, nutcracker syndrome and May-Thurner syndrome, resulting in a more precise diagnosis that is based on anatomy and underlying pathophysiology [4,12,13].
Venography is an invasive method requiring the administration of contrast. Diagnostic criteria of PVD using pelvic venography include ovarian vein diameter greater than 6 mm, contrast retention for longer than 20 seconds, stasis (of blood flow) in the ovary, pelvis, vulva and vagina or thigh, and visualization of reflux. Pelvic venography allows to obtain a detailed image of the anatomy of the veins before the embolization procedure. Moreover, it allows for the observation of reflux, which is not always possible in non-invasive imaging techniques, and most importantly, it allows for simultaneous intervention through pelvic vein embolization [13,14]. When appropriate imaging criteria are applied, conventional venography has a sensitivity of 91% and specificity of 89% in PVD diagnosis [11,15]. As premenopausal women

constitute the majority of CPP patients, consideration should be given to their unnecessary exposure to ionising radiation [7,16].

Although pelvic venography is still considered the gold standard in diagnosing PVD, non-invasive diagnostic imaging is instrumental in identifying patients with PVD [17].

This literature review aimed to evaluate the usefulness of non-invasive diagnostic imaging techniques like Transvaginal Ultrasonography (TVUS), Transabdominal Ultrasonography (TAUS), Magnetic Resonance (MR) and Computed Tomography (CT) in the identification of patients with PVD.

Material and Methods

Analysis of available literature indexed in PubMed, Cochrane and MEDLINE databases (original articles and reviews published between 1969 and 2023) was conducted between August 2022 and November 2023 using the following search terms combination: pelvic venous disorders OR chronic pelvic pain OR pelvic venous incompetence OR pelvic venous insufficiency OR pelvic congestion syndrome OR ovarian venous reflux OR pelvic venous reflux OR nutcracker syndrome OR May–Thurner, AND diagnostic imaging OR minimally invasive imaging techniques OR ultrasonography OR computed tomography OR magnetic resonance OR venography.

English-written abstracts analysing the problem of CPP (aetiology, differential diagnosis, diagnostic methods, and management strategy) were included in the literature analysis. Case studies, studies with insufficient/overlapping data and irrelevant outcomes have been excluded from the literature review.

After the revision of 1460 abstracts, full versions of scientific papers related to the topic were assessed for eligibility. The final sample was chosen from the 295 reviewed English-written full-text articles.

Results

Forty-one articles published between 1984 and 2023 were included in this literature review.

ULTRASONOGRAPHY

In the clinical practice of a gynaecologist, TVUS, in conjunction with TAUS, is the first method of screening/examination performed in patients with symptoms of CPP. PVD in TVUS may manifest as dilatation or tortuous aspects of ovarian veins, low blood flow (<3 cm/s) or reflux in ovarian veins and dilated arcuate vein in the myometrium communicating to pelvic varicosities [14,17–19]. Generally accepted imaging criteria that should be taken into consideration during diagnosis of PVD by TVUS include reflux (>1 s) and dilatation of the venous trunks on Valsalva, ipsilateral siphoning or contralateral dilation and syphon effects between the ovarian and internal iliac trunks, flow reversal in and distention of associated varices on Valsalva (Figure 1 a.b.c.) (Figure 2 a.b.c.) [20,21].

In the case of TVUS, when appropriate imaging criteria are applied, it has a sensitivity of 92.3% and specificity of 75% with false positive and false negative rates of 7.69% and 25%, respectively, for the detection of PVD [17].

Imaging criteria that should be considered during diagnosis of PVD by TAUS include dilatation (> 5 mm) of the ovarian vein with the reversed caudal flow, dilatation of arcuate veins and pelvic venous plexus (tortuous aspects) and variable duplex waveform in the varicoceles during the Valsalva [19,22,23]. Nonetheless, it should be noted that the diameter of the ovarian vein as an indicator of PVD remains debatable for researchers. A large-calibre ovarian vein may not show features of reflux, thus being asymptomatic. On the other hand, a small-diameter ovarian vein may show features of reflux, thus causing the typical symptoms of PVD described above [24]. Therefore, the assessment of reflux remains very important (Figure 3 a.b.). According to Steenbeek et al., in TAUS reversed, caudal flow in the ovarian vein accounted for a sensitivity of 100% for detecting PVD [23]. Furthermore, when appropriate imaging criteria are applied, TAUS has a sensitivity of 76% and specificity of 100% in the diagnosis of iliac vein obstruction and a sensitivity of 80% and specificity of 94% in the diagnosis of renal vein obstruction [25,26].

According to Malgor et al., TAUS demonstrate a sensitivity of 100% and specificity of 57% in the diagnosis of dilatation of the left ovarian vein and a sensitivity of 67% and specificity of 90% in the diagnosis of dilatation of the right ovarian vein [27].

MAGNETIC RESONANCE

The diagnosis of PVD is challenging. Delayed or incorrect diagnosis affects treatment efficiency and significantly reduces patients' quality of life, increasing the rate of the patient's morbidity and incidence of recurrence. Non-invasive diagnostic imaging techniques like MRI and CT play an essential role in diagnosis and appropriate management selection for patients with PVD. Exclusion of other potential causes of CPP mentioned above should be the primary goal of a proper diagnosis of PVD. The accurate diagnosis of pelvic venous insufficiency is the secondary goal. The management strategy decision is complex and depends on the causes of PVD, the severity of PVD and finally radiological findings [28]. PVD in conventional MR manifests as tortuous, dilated and enhancing tubular structures around the uterus, ovaries, ovarian veins, vaginal venous plexus, adnexa, and broad ligament [7,28-31].

Generally accepted imaging criteria for diagnosing PVD by MR venography have been described. Grade I includes venous reflux in the left ovarian vein and/or left parauterine veins, and Grade II additionally includes venous reflux in the right ovarian vein and iliac vein (left/right) [29–31]. In addition, MR and CT enable the evaluation of structures which evaluation in TVUS or TAUS may be limited, such as the left common iliac vein or the left renal vein [20]. (Figure 4 a.b.) (Figure 5 a.b.c.d.) (Figure 6 a.b.).

According to Asciutto et al., MR venography has a sensitivity of 88% and specificity of 67% for the detection of diseases located in ovarian veins, a sensitivity of 100% and specificity of 38% for the detection of diseases located in internal iliac veins and sensitivity of 91% and specificity of 42% for detection of diseases located in pelvic venous plexus [32]. Furthermore, Young et al. found no significant difference between time-resolved MR angiography and conventional venography for grading ovarian vein reflux [30].

COMPUTED TOMOGRAPHY

Compared to TVUS, TAUS and MR, CT is less frequently used in diagnosing PVD. Due to ionising radiation, CT scans should be used cautiously in premenopausal patients. Furthermore, CT is more expensive than TVUS or TAUS. Despite that, CT provides detailed anatomical information about the pelvis and abdomen and allows the exclusion of some of the other causes of CPP [7].

PVD in conventional CT manifests as tortuous, dilated and enhancing tubular structures around the uterus, ovaries, ovarian veins, vaginal venous plexus, adnexa, and broad ligament [33].

Diagnostic criteria of PVD in CT examination include identifying at least four ipsilateral pelvic veins (with a diameter of at least one vein greater than 4mm) and ovarian vein diameter greater than 8 mm. Obstructing mass lesions are absent [34]. Visualisation of reflux (like in the Valsalva manoeuvre) is possible during CT. Deep breath hold increases intraabdominal pressure in the supine position, inducing reflux [35]. Furthermore, it is possible to assess structures in which evaluation in TVUS or TAUS may be limited, such as the left common iliac vein or left renal vein [20].

According to Osman et al., CT has a sensitivity of 94.8% for the diagnosis of PVD. Furthermore, during the assessment of the diameter of the ovarian vein and the number and diameter of the pelvic varicose, no statistically significant differences were found between CT and conventional venography [34]. When appropriate imaging criteria are applied, CT has a sensitivity of 91.7% and specificity of 88.9% for detecting left renal vein obstruction [36]. Moreover, lower doses of contrast medium are required to perform CT venography [37].

Discussion

In conjunction with TAUS, TVUS is the first-choice method of PVD examination performed in a gynaecologist's clinical practice. These are cheap and non-invasive imaging techniques that can be performed during the same visit. Both TVUS and TAUS allow the evaluation of multiple pathologies that may contribute to CPP, like ovarian tumours, endometriosis, adenomyosis or uterine fibroids [17,38]. TVUS could be performed both in supine and semi-erect positions, offering more detailed imaging of anatomical structures involved in PVD [14,16]. In the case of disease at the more central level (inferior vena cava, iliac veins and renal veins), the image obtained by the TVUS may be less accurate compared to TAUS [14]. Furthermore, TAUS also allows an exclusion of some other described above causes of CPP that cannot be excluded using TVUS [14,22]. Unfortunately, the image obtained in the ultrasound examination may be distorted due to the body habitus and the presence of bowel gas obstructing venous structures despite adequate preparation for the test (at the clinic of the authors of the manuscript, the test is performed in the morning after 6 hours of fasting. Patients are asked not to eat fatty meals, dairy

products, and carbonated drinks the day before, and on the day of the procedure not to chew gum or smoke).

As described above, Valero et al. found that TVUS has a sensitivity of 92.3% and specificity of 75% with false positive and false negative rates of 7.69% and 25%, respectively, for the detection of PVD. The main limitations of this study were the small sample size and lack of intra- and interobserver reproducibility. Furthermore, patients were not adequately prepared for the test [17]. It was found that TAUS has a sensitivity of 100% and specificity of 57% in the diagnosis of dilatation of the left ovarian vein, sensitivity of 67% and specificity of 90% in the diagnosis of dilatation of the right ovarian vein, sensitivity of 76% and specificity of 100% in the diagnosis of iliac vein obstruction and a sensitivity of 80% and specificity of 94% in the diagnosis of renal vein obstruction. The main limitation of the cited studies was the small sample size. Furthermore, the study performed by Metzger at el. was cross-sectional and the study performed by Malgor et al. was retrospective [25–27]. Both TVUS and TAUS require much experience, and the results obtained may vary depending on the examinator's experience [23]. As the first-choice method of PVD detection in gynaecologists' clinical practice, TVUS and TAUS are very helpful and complement each other.

Although MR is more expensive than CT, it is used more extensively in diagnosing PVD in many centres. Compared to CT, it does not unnecessarily expose patients to ionising radiation, allowing precise assessment of pelvic and abdomen structures. Furthermore, MR enables the exclusion of some of the other causes of CPP. Unfortunately, due to the performance of the examination in the supine position, MR may underestimate venous pathology [7,32].

MR provides exquisite soft tissue contrast and allows excellent evaluation of the pelvic organs including visualization of the pelvic, perineal, vulval/labial, and thigh varices as well as dilatation of the ovarian vein [7,32,33].

Moreover, thanks to multiplanar imaging capability and high-quality soft-tissue contrast, secondary causes of PVD can be detected [39]. Tortuous veins with blood stasis can be visualized in high quality using the T2 Fat-Sat Spin echo sequence. MR venography with time-resolved imaging is a non-invasive and fast imaging technique that allows for the visualization of flow disturbances, which are often key to making the diagnosis. Data on pelvic anatomy as well as flow disturbances are also useful in developing the details of the embolization procedure. MR is reproducible, less expensive than conventional venography and non-irradiating in these young female patients [20,29,40,41].

MR enables clarification of any diagnostic doubts that appeared after TVUS or TAUS without exposing the patient to ionising radiation. However, it should be kept in mind that MR is a method that requires much experience in reading (more than CT), and the results obtained may vary depending on the experience of the operator [23].

It was found that MR has a sensitivity of 88% and specificity of 67% for the detection of diseases located in ovarian veins, a sensitivity of 100% and specificity of 38% for the detection of diseases located in internal iliac veins and a sensitivity of 91% and specificity of 42% for detection of diseases located in pelvic venous plexus. Moreover, Young et al. found no significant difference between time-resolved MR angiography and conventional venography for grading ovarian vein reflux. Both of studies have a small sample size. Furthermore, the study design by Young et al. was retrospective and there was no control group [30,32].

Compared to MR, CT is a lower-cost and more available imaging technique and therefore it is considered to be the method of choice by some for the diagnosis of PVD due to its highest temporal and spatial resolution with the advantages of 3D reconstruction images and post-imaging processing in the form of multiplanar reformatting. CT also enables precise assessment of pelvic and abdomen structures, which evaluation with TAUS or TVUS may be limited. Furthermore, lower doses of contrast medium are required to perform CT venography [37]. Unfortunately, CT does not allow for a detailed distinction of veins in the case of massive parametrial varicose veins and for dynamic evaluation of the venous flow [34].

It was found that CT has a sensitivity of 94.8% for the diagnosis of PVD, a sensitivity of 91.7% and a specificity of 88.9% for detecting left renal vein obstruction and that there is no statistically significant differences were found between CT and conventional venography. However, both of these studies were retrospective and there were problems with a control group [34,36]. In some cases, the use of CT may be appropriate. If it is not possible to perform MR, CT also enables to clarify any diagnostic doubts that appeared after TVUS or TAUS

However, due to ionising radiation, the application of CT in PVD diagnosis is limited.

Conclusion

Non-invasive imaging techniques seem to be crucial in diagnosing PVD. Currently, PVD-induced CPP is a treatable disease in the vast majority of patients.

Delayed or incorrect diagnosis affects treatment efficiency and significantly reduces patients' quality of life.

It should be kept in mind that all those non-invasive imaging techniques require much experience, and the results obtained may vary depending on the examiner's experience [23]. These non-invasive diagnostic imaging techniques should be performed according to standardised protocols considering generally accepted criteria. Undoubtedly, such management increases the sensitivity and specificity of tests. As presented above, the diagnostic criteria of PVD are not equal and vary between techniques. Firstly, the diagnostic criteria were based on various studies. Moreover, these differences may result from the way the tests are performed. The test result is influenced by, among others, the patient's position and the ability to cooperate with the patient (to induce reflux).

Diagnostic criteria and main advantages/disadvantages of all described above methods have been summarised in the form of a table [table 1].

Future studies investigating the role of non-invasive imaging techniques in diagnosing PVD are required.

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	Conventional Venography	TVUS	TAUS	MR	CT
Diagnostic Criteria	ovarian vein diameter greater than 6 mm contrast retention for longer than 20 seconds stasis (of blood flow) in the ovary, pelvis, vulva and vagina or thigh visualization of reflux	reflux (>1 s) dilatation of the venous trunks on Valsalva ipsilateral siphoning or contralateral dilation and syphon effects between the ovarian and internal iliac trunks flow reversal in and distention of associated varices on Valsalva	dilatation (> 5 mm) of the ovarian vein with the reversed caudal flow dilatation of arcuate veins and pelvic venous plexus (tortuous aspects) variable duplex waveform in the varicoceles during the Valsalva	Grade I - venous reflux in the left ovarian vein and/or left parauterine veins Grade II - includes additionally venous reflux in the right ovarian vein and iliac vein (left/right)	Identification of at least four ipsilateral pelvic veins (with a diameter of at least one vein greater than 4mm) ovarian vein diameter greater than 8 mm. Obstructing mass lesions are absent
Advantages	gold standard detailed image of the anatomy of the veins simultaneous intervention through pelvic vein embolization possible	first-choice/ screening method of PVD examination performed in a gynaecologist's clinical practice cheap no exposition to radiation exclusion of other causes of CPP	first-choice/ screening method of PVD examination performed in a gynaecologist's clinical practice cheap no exposition to radiation exclusion of other causes of CPP	precise assessment of pelvis and abdomen exclusion of other causes of CPP no exposition to radiation	precise assessment of pelvis and abdomen exclusion of other causes of CPP
Disadvantages	invasive technique exposition to radiation	technically difficult results obtained may vary depending on the examinator's experience distortion due to body habitus or inadequate preparation to test	technically difficult results obtained may vary depending on the examinator's experience distortion due to body habitus or inadequate preparation to test	results obtained may vary depending on the examinator's experience expensive	results obtained may vary depending on the examinator's experience expensive

Table 1. Diagnostic criteria, main advantages and disadvantages of conventional venography, TVUS, TAUS, CT and MR [7,11,13-23,28-31,33-37].