OVARIAN TORSION: FACTORS IMPACTING DIAGNOSIS

by

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Abstract

Ovarian torsion is a rare gynecological emergency that occurs when the ovary spontaneously becomes twisted on itself. If not recognized and treated, it can result in tissue necrosis and loss of the ovary. Ovarian torsion most frequently affects women and people with ovaries in their childbearing years, and if oophorectomy is required from missed diagnosis, this can result in decreased fertility of the individual. Due to the broad differential diagnoses present with abdominal pain, ovarian torsion diagnosis is challenging for clinicians. An integrative review of available data was completed to determine factors that impact the diagnosis of ovarian torsion in adult non-pregnant women who present to the emergency department. A literature search was conducted using databases MEDLINE and CINAHL for articles in English and studies published from 2000-2025. A total of 12 papers were reviewed and data extraction completed to ascertain common factors impacting the diagnosis of ovarian torsion. Methods of diagnosis for ovarian torsion include patient history and clinical exam, bloodwork and urinalysis, and imaging via ultrasound and/or computed tomography. There has been improvement in ovarian salvage rate in the last 20 years, possibly due to increased preference for attempting ovarian salvage versus oophorectomy even if ovaries appear dusky on initial exam. No single physical exam or diagnostic can rule out torsion definitively, and care should not be delayed obtaining an ultrasound if high suspicion for ovarian torsion. The gold standard for diagnosis and treatment of ovarian torsion remains operative exploration, and clinicians should not hesitate to involve obstetrics and gynecology promptly when they suspect a patient has ovarian torsion.

Keywords: ovarian torsion, adnexal torsion, factors affecting diagnosis, diagnostic process, emergency department, emergency room

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Glossary

Term	Definition
Clinician	Someone who makes a diagnosis. Includes both physicians and Nurse Practitioners. The words 'clinician(s)' and 'provider(s)' are interchangeable.
Cyst	Membranous sac containing fluid.
Emergency department (ED)	Also referred to as Accident & Emergency (A&E). Medical facility or area of a hospital that specializes in treating critically ill or acute patients without prior appointment.
Laparoscopy	Surgical technique. Uses small incisions and a camera know as laparoscope to treat abdominal or pelvic conditions.
Necrosis	Death of most or all the cells in an organ or tissue.
Oopherectomy	Surgical removal of one or both of the ovaries.
Ovarian torsion	Also referred to as adnexal torsion. When the ovary spontaneously becomes twisted on itself. Interchangeable with 'torsion' for the purposes of this paper.
Polycystic Ovarian Syndrome (PCOS)	Hormonal disorder in women or people with ovaries of reproductive age. Characteristics include irregular menses, high androgen levels, and ovaries with multiple cysts.
Salpingo-oophorectomy	Surgical removal of the fallopian tubes and ovaries.

Chapter One: Introduction & Background

Ovarian torsion, also known as adnexal torsion, is a rare gynecological emergency that occurs when the ovary spontaneously becomes twisted on itself. Ovarian torsion accounts for 2-3% of all emergency department (ED) visits for acute lower abdominal pain (Ashmore et al., 2023; Silber et al., 2021), with an incidence of 157.4 cases of torsion per 100,000 emergency department visits by women of reproductive age (Tabbara et al., 2024). The words woman, women, and female(s) will be used throughout this paper to refer to study subjects as well as the population affected by ovarian torsion. It is important to recognize that not all people with ovaries may identify as women or as female and minority groups such as sexual minority groups such as trans and non-binary individuals are often excluded from academic research (Iheagwara et al., 2023; Rickman et al., 2022).

Ovarian torsion occurs when the ovary rotates with the ligamentous structures of the pelvis, and can involve the adjacent fallopian tube, which are referred to together as adnexal structures (Ashmore et al., 2023). If ovarian torsion is not corrected in a timely matter, it can lead to organ necrosis, sepsis, need for oophorectomy, and loss of fertility in the affected patient (Campo, 2009; Shyy et al., 2018; Tabbara et al., 2024; White & Stella, 2005). Acute abdominal pain, a symptom of ovarian torsion, is a challenging patient complaint due to the large number of differential diagnoses, particularly in women of childbearing age as complications of pregnancy must also be ruled out in addition to other pathologies such as appendicitis, diverticulitis, bowel obstruction and perforation, ectopic pregnancy, miscarriage, and kidney pathologies (Campo, 2009; Tabbara et al., 2024; White & Stella, 2005).

The presence of ovarian cysts is one of the most common reasons for misdiagnosis of ovarian torsion (Cohen et al., 2001b). Misdiagnosis accounts for more medical litigation than any other medical error and often occurs due to several breakdowns in the diagnostic process (Lippman & Davenport, 2010). A common breakdown in the diagnostic process is a cognitive error known an anchoring bias, where the provider anchors on a specific diagnosis and finds reasons to support the initial diagnosis instead of completing an appropriate examination and work-up. If a diagnosis is already mentioned in the patient's chart or in the triage documentation, for example ovarian cyst, it has been demonstrated that providers are more likely to anchor on such diagnosis and potentially miss other causes they would have reached if they recognized and anchoring bias (Ly et al., 2023).

The purpose of this review was to analyze factors impacting the diagnosis of ovarian torsion to increase clinician confidence and knowledge of common diagnostic errors and/or delays. Although ovarian torsion remains a rare condition, the potential consequences of a missed diagnosis remain severe and increase clinician competence in awareness and diagnosis of the condition have the potential to improve patient care and decrease the potential for complications (Ashmore et al., 2023; Campo, 2009; Kroger-Jarvis et al., 2018; Tabbara et al., 2024).

The following paper is an integrative review of available data on factors that impact the diagnosis of ovarian torsion in adult non-pregnant women who present to the emergency department. Risk factors that may increase someone's likelihood of developing ovarian torsion, and several diagnostic tools clinicians can use to assist in obtaining diagnosis will first be reviewed.

Databases MEDLINE and CINAHL were used to conduct a literature search of available research from the last 25 years on diagnosis of ovarian torsion in women in emergency department environments. A summary of the findings will be presented along with implications for clinical practice to assist clinicians in improving their diagnostic process in patients for whom ovarian torsion is one of the differential diagnoses.

Risk Factors

Ovarian Cysts

The most common risk factor for development of ovarian torsion is the presence of large ovarian cysts, most often between 5 and 10 centimeters in diameter (American College of Obstetricians & Gynecologists, 2019; Zhu & Li, 2024). Ovarian cysts increase the risk of torsion by destabilizing the ovary and causing it to twist around the suspensory ligament of the ovary, leading to compression of the ovarian vessels (Ashmore et al., 2023). Cysts that cause ovarian torsion are most likely to be non-cancerous in nature and their presence may or may not be known previously to the patient. Malignant masses are more likely to cause adhesions within the pelvis and therefore not result in torsion of the ovary as the structures are not free-floating within the pelvis (Ashmore et al., 2023; Long et al., 2020).

Hormonal Factors

Hormonal factors such as ovarian hyperstimulation during fertility treatments, pregnancy, and polycystic ovarian syndrome (PCOS) all increase the risk of ovarian torsion. Fertility treatments as well as PCOS can lead to increased overall size of the ovaries and the development of one or multiple large ovarian cysts (Ashmore et al., 2023; Tabbara et al., 2024; Zhu & Li, 2024). It is not well known why pregnancy is a risk factor for ovarian torsion, however most likely is the displacement of the ovaries by the gravid uterus as well as

more difficulty in diagnosis due to the gravid uterus making ovaries more difficult to locate on physical and ultrasound exam (Ashmore et al., 2023; Long et al., 2020).

Other Risk Factors

Women of reproductive age and those with a prior history of ovarian torsion are at increased risk of torsion (Ashmore et al., 2023; Zhu & Li, 2024). It is likely that multiple factors increase risk in the above groups, including hormonal factors and the presence of reoccurring cysts. Ovarian torsion can also present in children, with right-sided torsion being more common than left (Ashmore et al., 2023; Zhu & Li, 2024), and is most likely due to longer suspensory ligaments or lack of protective bowel overlying the right ovary allowing more ovarian movement within the pelvis (Ashmore et al., 2023).

Diagnosis

Overview

Ovarian torsion is a challenging diagnosis due to the wide differential diagnoses for a patient with abdominal pain. The classic presentation of ovarian torsion is sudden onset severe pain in the right or left lower abdominal quadrant, with significant ovarian enlargement or reduced doppler flow on ultrasound (Ashmore et al., 2023; Campo, 2009; Shyy et al., 2018; Silber et al., 2022; Tabbara et al., 2024; White & Stella, 2005; Zhu & Li, 2024). Patients who present in the typical fashion can be quickly referred to laparoscopic surgery for ovarian salvage (Tabbara et al, 2024). However, many patients do not present with symptoms specific to ovarian torsion and a diagnosis is made once other gynecological or abdominal pathologies are excluded. Conditions that often have overlapping symptoms of ovarian torsion include appendicitis, ectopic pregnancy, ovarian cysts, pelvic inflammatory

disease, endometriosis, benign or malignant pelvic masses, diverticulitis, and bowel obstruction (Campo, 2009; Shyy et al., 2018; Zhu & Li, 2024).

Physical Exam & Laboratory Findings

A detailed history, physical exam, and laboratory findings can be analyzed together to gain a more thorough clinical picture and assist the clinician in determining a patient's risk for ovarian torsion. Patients often present to the ED due to severe abdominal pain (Tabbara et al, 2024; White & Stella, 2005), but patients may also describe pain that is intermittent due to an ovary that is torting and de-torting or describe increasing pain over several days (Shyy et al, 2018). White & Stella (2005) found that some women did not present to the ED until they had 3 days of abdominal pain and only presented due to the increasing severity of their pain. On external exam, a palpable mass and guarding may be present. On bimanual exam, patients may report unilateral adnexal tenderness. Bloodwork and urinalysis will not confirm diagnosis but can assist to exclude other abdominal causes such as infection or pregnancy. Elevated white blood cell (WBC) count, fever, and peritoneal signs may occur, however often this is accompanied by ovarian necrosis and is a late finding (Campo, 2009; Tabbara et al, 2024).

Diagnostic Imaging

Both ultrasound and computed tomography (CT) are often used as investigations to confirm ovarian torsion. Ultrasound has often been used to decrease patient exposure to radiation and is often present in more rural locations which may not have a CT scanner (Shyy et al., 2018). Providers trained in point of care ultrasound (POCUS) can complete this exam bedside for expedited results. Common findings include ovarian enlargement, pelvic free fluid, and reduced arterial or venous flow on doppler ultrasound (Shyy et al., 2018; Silber et

al., 2022; Swenson et al., 2014). CT is more often performed initially on patients that are suspected of having other pathology, such as renal colic. There is less literature on CT findings specific to ovarian torsion, however unilateral ovarian enlargement on CT is often a finding on exam (Shyy et al., 2018).

Laparoscopy (Gold Standard)

Diagnostic laparoscopy remains the gold standard for definitive diagnosis and treatment of ovarian torsion. Previously, standardized treatment was salpingo-oophorectomy via laparotomy due to the concern that a necrotic-appearing ovary could trigger a thromboembolic event (American College of Obstetricians and Gynecologists, 2019; Kroger-Jarvis et al., 2018 Novoa et al., 2021). No thromboembolic events have been documented in over 100 years, therefore ovarian salvage is generally attempted for all ovaries that are non-necrotic in appearance, even if they appear blue or dusky in colour (Campo, 2009; Novoa et al., 2021). Many ovaries that appear to be non-viable on initial detorsion show follicular development several days following surgery (American College of Obstetricians and Gynecologists, 2019; Kroger-Jarvis et al, 2018; Novoa et al., 2021; White et al, 2005).

Patient Impact

If ovarian torsion is not recognized and corrected, necrosis will occur, and organ loss will ultimately occur. It is unclear how long a torsed ovary is viable for, however little ovarian salvage has been reported beyond the 72-hour period (White & Stella, 2005; Tabbara et al., 2024), and this is likely impacted by how many times the ovary is torsed around the adnexa and if blood flow is preserved or not (Tabbara et al., 2024). Increased time to diagnosis and ovarian necrosis also puts the patient at increased risk for developing complications such as peritonitis and sepsis (Campo, 2009). Given that ovarian torsion most

often affects women of reproductive age, with a mean age of 27.3 (Tabbara et al., 2024) to 33.5 years of age (White & Stella, 2005), it is important to note that the loss of an ovary may impact future family-building plans of the affected individual.

Many researchers describe the diagnostic challenges of ovarian torsion, and the negative impact delayed diagnosis has on patients (American College of Obstetricians and Gynecologists, 2019; Campo, 2009; Novoa et al., 2021; Tabbara et al., 2024; White & Stella, 2005). The purpose of this review is to explore current knowledge and recommendations of how to quickly and accurately diagnose ovarian torsion, and to explore what factors affect diagnosis. A better understanding of factors that impact the diagnosis of ovarian torsion can help providers be more confident about the recognition and diagnosis of torsion and improve ovarian salvage and patient outcomes.

Chapter Two: Methods

Design

The population-issue-outcome of interest (PIO) format (Josewski, 2024) was used to format the following research question: “What factors impact the diagnosis of ovarian torsion in adult non-pregnant women who present to the emergency department?”. The alternative population-intervention-comparison-outcome (PICO) format for research questions was not appropriate in this instance as a specific intervention was not being studied, therefore this was not a synthesis of data for an intervention versus a control group. In studying medical outcomes, it is often not ethically appropriate to offer one group an intervention and withhold such intervention from another group. In this instance, it would not be appropriate to offer one group of women with suspected ovarian torsion surgical intervention and another group no surgical intervention, therefore most of the research examined was retrospective or prospective case reviews.

Search Terms

Search terms were developed to fully encompass standardized variations of the keywords in the research question. Common regional variations were included, such as ‘accident and emergency’ versus ‘emergency department’. A grey literature search was also conducted using Google search engine to browse common variations of the term ovarian torsion, such as adnexal torsion. Table 1 shows the final subject headings and terms used.

Table 1

Subject headings and terms used

		Subject Headings & Search Words Used with Truncation
Population	Adult non-pregnant women	MH "adult" or MH "women" or MH "female", adult* OR female* OR woman OR women
	Emergency department	MH "emergency service, hospital", emergency department OR ed OR a&e OR accident and emergency OR emergency room OR er
Issue	Ovarian torsion	MH "ovarian torsion", ovarian torsion OR adnexal torsion
Outcome of interest	Diagnosis	MH "diagnostic techniques and procedures" or MH "diagnosis", clinical diagnosis OR diagnosis OR finding

Search Strategy

Databases MEDLINE (via EBSCO) and CINAHL (via EBSCO) were chosen for the literature search. MEDLINE was chosen to encompass biomedical research applicable to medical and nursing professions. CINAHL was chosen for the focus on nursing and allied health literature. Appendices A and B show the full step by step search strategy in both MEDLINE and CINAHL.

The MEDLINE database search required the use of the 'not' operator following the initial search as initially 129 articles were retrieved, many of them focusing on exclusively pregnant or pediatric patients. The operator 'not preg* and not ped*' was added after the final search to finalize the MEDLINE database search to 52 total articles for review.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were chosen such that data may be extrapolated to a general reproductive-age adult female population. The emergency department was chosen to capture the full diagnostic process from initial presentation to surgery in patients with ovarian torsion. Pediatric and exclusively pregnant patients were excluded to have results

that could be applied to a general adult population, due to a large volume of research done exclusively on these populations, and because ovarian torsion most often affects young adult women of childbearing age (Ashmore et al., 2022; Tabbara et al, 2024; White & Stella, 2005). Studies from the years 2000-2025 were chosen to capture five- and ten-year retrospective studies in this review, to include seminal research, and to analyze if major changes in standard of care could be captured.

Inclusion criteria were as follows:

- Study written in English
- Participants presented to the emergency department
- Primary literature
- Study published between 2000-2025

Exclusion criteria were as follows:

- Outcome of interest is not diagnosis or recognition of ovarian torsion
- Study subjects are under the age of 18
- Study subjects are exclusively post-menopausal
- Study subjects are exclusively pregnant

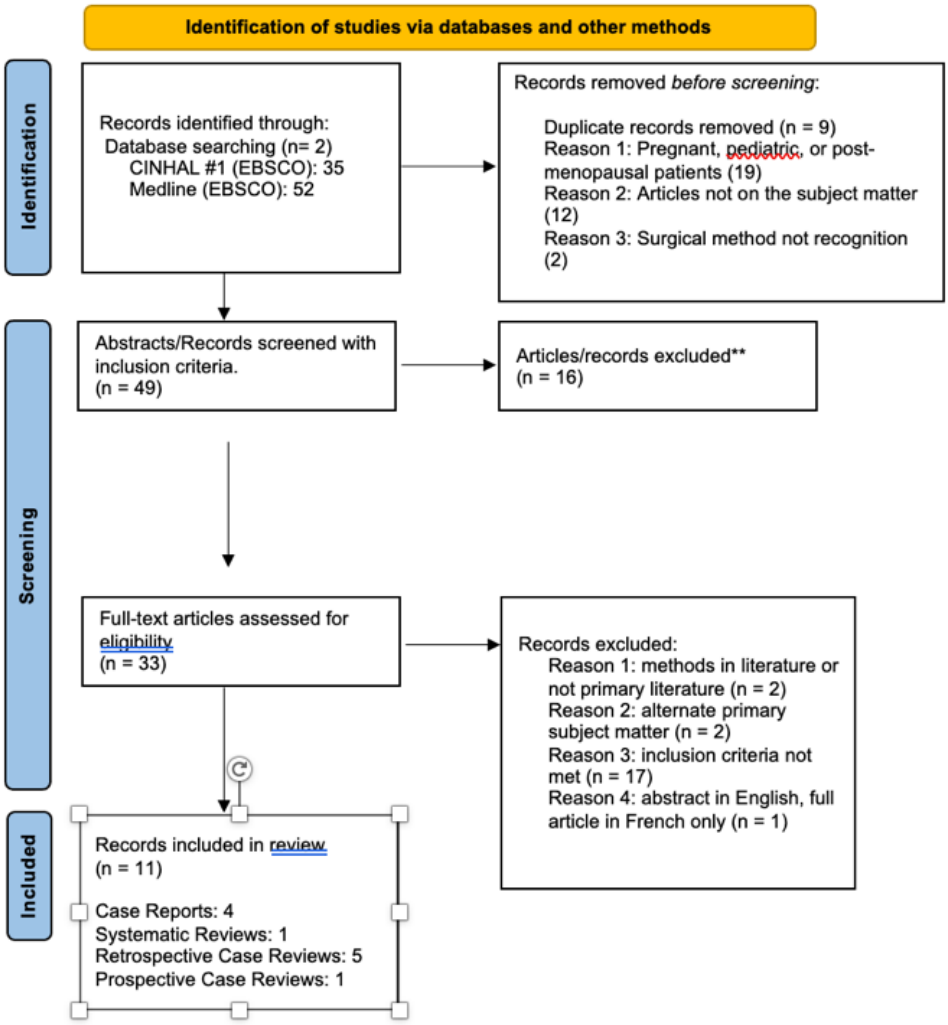
Data Evaluation

Following the initial search, 87 articles were retrieved from MEDLINE and CINHAL searches combined, with 42 records being removed prior to initial screening. Initial screening of 49 articles was completed using inclusion and exclusion criteria and reviewing articles abstracts, after which 16 articles were further excluded. A total of 33 full-text articles were assessed for eligibility and a further 22 articles excluded due to issues in methodology or not being primary literature (two), alternate primary subject matter (two), inclusion criteria not

met (17), and full article being in the French language (one). Figure 1 highlights the identification, screening, and final inclusion details of articles in this review.

Figure 1

PRISMA Diagram Illustrating Narrowing of Searches



PRISMA 2020 flow diagram adapted from Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

The Joanna Briggs Institute (JBI) critical appraisal tools (JBI, 2020) were used to critically appraise all articles; full analysis and data extraction can be found in Appendix C and Appendix D**.** A rating system from 1 to 5 was created based on the JBI critical appraisal tools for case series and case studies (JBI, 2020; Munn et al., 2020). Articles were given a rating system from 1 to 5 to visually assist in weighting articles for appraisal, with 1 being the lowest and 5 being the highest rating. Prospective and retrospective case reviews were weighted more highly for analysis given the large sample size, higher external validity, and consecutive enrolment of subjects (Munn et al., 2020). Case reviews were included if they clearly described the demographic characteristics and presenting clinical condition and exam of the individual, and if the case review reported clearly on diagnostic components, adverse events, and clinical takeaways or learning points (JBI, 2020).

Additional Searches and Citation Searching

The primary literature search resulted in two articles on the serum biomarker interleukin-6 (IL-6) (Cohen et al., 2001a; Christopoulos et al., 2013). These articles matched the inclusion and exclusion criteria, and a secondary search was completed to ensure accurate recent research was included in the analysis. The most recent systematic review including serum IL-6 in the diagnosis of ovarian torsion was included to ensure accurate and up-to-date synthesis of literature (Naylor et al., 2024). The literature review from Naylor et al. (2024) did not meet the initial inclusion criteria as the review also encompasses animal trials and does not state if patients presented to the emergency department, however as this was a systematic review and not a primary research study it was included in data analysis.

Table 2

Secondary search terms used for serum biomarker interleukin-6

Search Terms	**Filter Applied**	**Results**	**Systematic Reviews Included**
	Articles since 2010 English language	58	1 (Naylor et al., 2024)
Ovarian torsion or adnexal torsion	Search with OR		
MH "Ovarian Torsion"			
Biomarkers or biological markers or biomarker or biological marker	Search with OR		
MH "Biomarkers/BL"			

Chapter Three: Findings

Findings were divided into factors identified from research synthesis, and included patient history and physical exam, diagnostic findings, and future non-invasive diagnostics. A total of 5 retrospective case reviews, 1 prospective case review, 2 systematic reviews, and 4 case reports were analyzed in this integrative review. Study locations were primarily university-affiliated or tertiary hospitals (Cohen et al., 2001b; Shyy et al., 2018; Silber et al., 2022; Tabbara et al., 2024; White & Stella, 2005). One study location was a pediatric hospital (Otjen et al., 2015), one was a gynecological hospital (Cohen et al., 2001a), one was a small-community hospital (Kroger-Jarvis et al., 2018), one was a multicenter study (Swenson et al., 2014), and in one study the location was not available (Campo, 2009). All study participants presented to the emergency department, which was part of the inclusion criteria for this review. In all the studies analyzed, there was no comment on the gender identity of the subjects and the words woman, women, and female(s) were used, therefore the results cannot be extrapolated to also include the trans and non-binary community. A brief search of the literature on ovarian torsion in the transgender community resulted in one case study highlighting a case of bilateral ovarian torsion in a transgender female-to-male patient (Rickman et al., 2022), highlighting the lack of research in this community however also the rarity of the condition, as Rickman et al. (2022) also report that in their review only 7 cases of bilateral ovarian torsion case studies were published in the literature.

The locations of studies were broad; three studies took place in Israel (Cohen et al., 2001a; Cohen et al., 2001b; Silber et al., 2022), one in Lebanon (Tabbara et al., 2024), one in Australia (White & Stella, 2005), and four in the United States (Campo, 2009; Otjen et al., 2015; Shyy et al., 2018; Swenson et al., 2014). Only one study was completed outside a large

urban center (Kroger-Jarvis et al., 2018). Specific details of the type of study, study locations, and geographic location of studies are outlined in Appendix D. Finding were divided into the following categories: patient history, physical exam, ultrasound, computed tomography, and future directions involving non-invasive biomarkers.

Patient History & Physical Exam Findings

Patient History

With a comprehensive patient history and physical exam, the differential diagnoses include appendicitis, cystitis, diverticulitis, ectopic pregnancy, endometriosis, bowel obstruction, nephrolithiasis, ovarian cysts, kidney stones, and pelvic inflammatory disease (Campo, 2009; Kroger-Jarvis et al., 2018). The most common symptoms associated with ovarian torsion include sudden onset lower abdominal pain, known risk factors for ovarian torsion, and nausea or vomiting, (Campo, 2009; Kroger-Jarvis et al., 2018; Otjen et al., 2014; White & Stella, 2005).

Kroger-Jarvis et al., (2018), Otjen et al., (2014), & White & Stella, (2005) all found that abdominal pain is most commonly right-sided, sudden in onset, and unrelieved with over-the-counter medications or position changes. In their retrospective case series, Tabbara et al. (2024) reported that 95% of patients in their study presented to the ED due to abdominal pain. The finding by Tabbara et al. (2024) confirm results by White & Stella (2005), whose 10-year retrospective case review reported sudden abdominal pain was a symptom in 87% of patients with ovarian torsion. However, case studies conducted by Campo in 2009 demonstrated that torsion cannot be excluded in left lower quadrant abdominal pain. Patient report of sudden, severe pain being associated with torsion differs slightly from those reported by Shyy et al. (2018), who note a case torsion where the onset of

pain was gradual, described as crampy and intermittent, and was relieved with over-the-counter ibuprofen.

White & Stella (2005) reported at the time of clinician assessment, 30.8% of patients had a known risk factor such as an ovarian cyst, and these patients tended to be diagnosed more quickly compared to those without known risk factors (12 hours to diagnosis with risk factors versus 26 hours without). White & Stella's 2005 findings highlighted multiple risk factors, of which ovarian cysts are included. Tabbara et al. (2024) had somewhat different results and reported that 75% of patients with ovarian torsion had one or more ovarian cysts. Tabbara et al., (2024) did not compare time to diagnosis in patients with risk factors for torsion versus those without, therefore how time-to-diagnosis findings are affected by risk factors as addressed by White & Stella (2005) are unable to be compared with the findings of Tabbara et al. (2024).

In addition to lower abdominal pain, nausea and vomiting was a commonly reported finding. Research completed by both Tabbara et al. (2024) and White & Stella (2005) was conducted via retrospective case reviews. Tabbara et al., (2024) utilized data from electronic chart reports over a one-year period, while White & Stella (2005) reviewed data over a 10 year period and do not state whether chart data was electronic or paper. Symptom information was presented in table format by both Tabbara et al. (2024) and White & Stella (2005) and whether this is patient versus clinician report of symptoms was not differentiated. Tabbara et al. (2024) reported 90% of patients had these symptoms, which is significantly higher than White & Stella (2005) who reported 59% of patients with nausea and vomiting. Of the case reports reviewed, interestingly only one reported the symptom of nausea and vomiting (Kroger-Jarvis et al., 2018), with the remaining three studies noting absence of

nausea and vomiting (Campo, 2009; Otjen et al., 2015; Shyy et al., 2018). This could mean that although nausea and vomiting was one of the most common symptoms in patients with ovarian torsion, the absence of nausea and vomiting, although it appears rare, does not exclude ovarian torsion as a potential diagnosis. Time from symptom onset to presentation to the ED varied, with some patients presenting within hours of symptom onset (Campo, 2009; Kroger-Jarvis et al., 2018; Otjen et al., 2015; Shyy et al., 2018; Tabbara et al., 2024) and some others waiting greater than 72 hours to present to the ED (White & Stella, 2005).

Physical Exam

In patients with ovarian torsion, the most common physical exam findings were abdominal tenderness on exam and a palpable abdominal mass (Tabbara et al., 2024; White & Stella, 2005). The incidence of abdominal tenderness and palpable abdominal mass was similar between Tabbara et al. (2024) and White & Stella (2005), with 65% of patients reporting abdominal tenderness on external abdominal physical exam (Tabbara et al., 2024) and 62.2% of patients presenting with a palpable abdominal mass (White & Stella, 2005). Shyy et al. (2018) also report abdominal tenderness as the most common physical exam finding. Peritoneal signs such as abdominal rigidity, guarding, and rebound tenderness were present in 10-15% of patients (Tabbara et al., 2024).

The findings overall demonstrate sudden onset lower abdominal pain, palpable abdominal mass, known risk factors for ovarian torsion, and nausea and vomiting are associated with ovarian torsion, the absence of these symptoms should not exclude ovarian torsion from the differential diagnosis.

Diagnostic Findings

Bloodwork, Urinalysis, & Vital Signs

Many of the studies reviewed noted the importance of bloodwork and urinalysis as a component to diagnosis in order to rule out other common causes of acute abdominal pain, such as appendicitis or ectopic pregnancy (Campo, 2009; Kroger-Jarvis et al., 2018; Shyy et al., 2018; Tabbara et al., 2024; White & Stella, 2005). While Tabbara et al. (2024) reported 10-15% of patients presented with peritoneal signs and 5% with fever, Campo (2009) noted that fever, peritoneal signs, and elevated white blood cell count are late findings in ovarian torsion. Bloodwork including a white blood cell count and kidney function should remain within normal limits in early ovarian torsion, and a urinalysis should be done to rule out pregnancy or acute kidney disorders (Campo, 2009; Kroger-Jarvis et al., 2018; Shyy et al., 2018; Tabbara et al., 2024). This differs slightly from the report by White & Stella (2005), who noted elevated WBC in 20.6% of patients and fever in 19.6% of patients. As with a complete patient history and physical exam findings, researchers agreed that bloodwork and urinalysis results cannot confirm ovarian torsion, but can help to exclude other conditions causing acute abdominal pain.

Ultrasound & Computed Tomography

Ultrasound and computed tomography (CT) are both imaging modalities that may assist a clinician in diagnosing ovarian torsion. Ultrasound is preferred as it is often more easily accessible compared to CT, can be completed as a bedside exam, and to reduce patient exposure to radiation (Kroger-Jarvis et al., 2018; Silber et al., 2022). Ultrasound has also been previously viewed as more sensitive when compared to CT in detecting ovarian torsion,

however, neither imagining modality is entirely diagnostic for torsion. Unfortunately, there is little research on using CT also as a diagnostic modality for ovarian torsion.

Swenson et al. (2014) reported CT as being 90-100% sensitive and 85-90% specific for ovarian torsion, versus ultrasound which was 80% sensitive and 85-95% specific for torsion. A limitation of their study was the small sample size of only 20 patients. The sensitivity and specificity of ultrasound is relatively similar as reported by Tabbara et al. (2024), who reported 70-72% sensitivity and 87-99.6% specificity for ultrasound in diagnosis of ovarian torsion. The specificity reported is the highest reported in all studies examined in this report. However, these findings also demonstrate relatively little change in ultrasound detection of torsion over a 10-year period. In case reports, abnormal CT findings have been re-confirmed with ultrasound. Shyy et al. (2018) report on a case in which a CT scan was done which showed concern for torsion, however the exam was repeated with ultrasound which also confirmed ovarian torsion. For this patient, the organ was deemed necrotic and the patient had an oophorectomy.

Both transabdominal and transvaginal ultrasounds often display abnormal findings in ovarian torsion, and there is no difference in exam findings whether they are completed abdominally or vaginally (Silber et al., 2022). The accuracy of ultrasound as a diagnostic tool varies widely and depends on the ultrasound parameters measured. White & Stella (2005) reported all ultrasounds in patients with ovarian torsion were found to be abnormal, with abnormal results including ovarian cysts/masses, enlarged ovary, or free intraperitoneal fluid. A limitation with this report is the authors did not comment on findings that were specific to ovarian torsion, and not a benign finding.

Ultrasound shows varying sensitivity and specificity depending on provider expertise, with 64.4% of point of care ultrasound trained emergency department staff correctly diagnosing torsion via ultrasound (Silber et al., 2022). Expert sonographers utilize a greater number of sonographic parameters when compared to bedside clinicians and formal ultrasound is preferred if available (Silber et al., 2022). A common pitfall with ultrasound is relying on results of doppler blood flow, which is decreased in only 50% of cases of ovarian torsion and should not be used to rule out torsion (Tabbara et al., 2024). Ultrasound findings that are often present in ovarian torsion include ovarian cyst, ovarian edema, and change in size or position of ovary compared to previous imaging (Otjen et al., 2015; Silber et al., 2022; Tabbara et al., 2024; White & Stella, 2005). CT has shown very high sensitivity and specificity for diagnosing ovarian torsion (Swenson et al., 2014), however, is not the preferred method of imaging due to exposure to radiation.

Operative Diagnosis

Currently the only definitive way to definitively diagnose and correct ovarian torsion is surgically through laparoscopy or open laparotomy, as clinical diagnosis remains challenging (American College of Obstetricians and Gynecologists, 2019; Novoa et al., 2021). A pre-operative diagnosis of ovarian torsion was only confirmed surgically in 44% of patients as reported by Cohen et al. (2001). Non-invasive diagnostics such as physical exam, lab tests, and imaging can be useful tools however lack the sensitivity and specificity needed to confidently diagnose torsion.

Future Non-Invasive Diagnostics Using Serum Biomarkers

Serum interleukin-6 (IL-6) is a cytokine that may contribute to the local inflammatory response in ovarian torsion (Naylor et al., 2024). Several studies have hypothesized that IL-6

elevation is a promising biomarker in ovarian torsion and could be incorporated as a diagnostic tool. Three studies on serum biomarkers, specifically IL-6 were included in the analysis, one prospective care series (Cohen et al., 2001), and two systematic reviews (Christopoulos et al., 2013; Naylor et al., 2024). The exclusion criteria by both Cohen et al., (2001) and Christopoulos et al. (2013) reflected the exclusion criteria used in this review; pregnant women, those with underlying malignancy, and those with obvious secondary medical conditions were excluded. Naylor et al. (2024) completed a systematic review and meta-analysis on the use of several biomarkers in the detection of ovarian torsion using both animal and human models. This review was chosen to ensure data analysis reflected current research since seminal work was completed by Cohen et al. in 2001.

Cohen et al. (2001) reported 75% of patients with surgically confirmed ovarian torsion had elevated serum IL-6, and that no patients without surgically confirmed ovarian torsion had elevated serum IL-6, therefore making IL-6 75% sensitive and 100% specific for ovarian torsion in this study. The authors acknowledge a large limiting factor of this study is the small sample size, with only 20 study participants total and only 8 with surgically confirmed ovarian torsion.

Christopoulos et al. (2013) completed a systematic review of serum IL-6 and ovarian torsion and found a total of only two articles meeting their inclusion criteria for analysis, including the work by Cohen et al. (2001). Christopoulos et al. (2001) report IL-6 was 85.7% sensitive for ovarian torsion, however they did not include the specificity. While this is a higher sensitivity than reported by Cohen et al. (2001), a lack of report on the specificity weakens the strength of their findings.

Naylor et al. (2024) completed a broad systematic review focusing on eight total biomarkers in ovarian torsion in both animals and humans. Naylor et al. (2024) note that IL-6 was the most observed biomarker in human studies of ovarian torsion, however they also reported increased IL-6 levels in appendicitis. This finding differs from those by (S. B. Cohen et al., 2001), who did not find any increase in IL-6 in appendicitis. The sensitivity and specificity findings reported by Naylor et al. (2024) cannot be applied to this review as they combined the sensitivity and specificity results from eight different biomarkers in total and examined both human and animal models. However, the authors reported IL-6 had the highest sensitivity of all biomarkers assessed in their review (Naylor et al., 2024). The biomarker serum IL-6 may be a promising component in the diagnosis of ovarian torsion in the future, yet current research is limited by small trial sample size and lack of standardization between trials. Additionally, no point of care testing for IL-6 currently exists and not all hospital laboratories have the capability to process serum IL-6 results (Christopoulos et al., 2013; Naylor et al., 2024).

Limitations of Findings and Other Potential Factors

A major challenge in synthesis and interpretation of the chosen studies was how the authors' presented their findings and the level of detail they provided in their articles. Tabbara et al. (2024) presented chart data of each patient in their study including time-to-ultrasound, time-to-surgery, number of times the ovary was twisted on itself, outcome, and primary reported symptoms. This contrasts with other retrospective studies such as that by White & Stella (2005) who reported on most common reported symptoms, such as sudden and severe lower abdominal pain, but did not provide charts or graphs with data on each patient in their study or state how their data on reported symptoms were gathered. Case study

data gave insight into how patients may present in a non-classic fashion, such as the case detailed by Shyy et al. (2018), in which their patient reported abdominal pain which was resolved with over-the-counter medication. Case study data was not weighted as heavily as systematic reviews or retrospective/prospective case series, given that the number of subjects in each case study is one. However, case studies do show us that abnormal presentations of ovarian torsion, such as pain that is relieved by over-the-counter medications and not reported as severe (Shyy et al., 2018), so exist and clinicians should not assume all patients with torsion will have sudden and severe abdominal pain.

There are several other potential factors that were of interest that were not discussed in the literature reviewed, and therefore the research question was only answered in partial. Firstly, all prospective and retrospective case series took place in large urban centres (Cohen et al., 2001a; Cohen et al., 2001b; Silber et al., 2002; Tabbara et al., 2024; White & Stella, 2005), and only one case study location was a rural site (Kroger-Jarvis et al., 2018). Therefore, we cannot extrapolate the research to determine whether rural versus urban diagnostic sites may impact diagnosis. Secondly, information on providers involved was missing in the data from the studies reviewed. Topics that are of interest for further review and were not found in this literature search include: provider experience in years since graduation, self-reported comfort in diagnosing torsion, and any additional post-graduate training completed. Thirdly, comprehensive data on time from presentation to surgery was lacking and only presented in one study (Tabbara et al., 2024), therefore factors that lengthened time-to-diagnosis, such as lack of operating room space and availability of specialists, could not be accurately analyzed given lack of data.

Chapter Four: Discussion

This integrative review was completed to answer the question "what factors impact the diagnosis of ovarian torsion in adult non-pregnant women who present to the emergency department?". The research demonstrated the answer to this question is multi-factorial, with several overlapping factors and diagnostic modalities that must be examined together and not solely in isolation. Factors identified that impact the diagnosis of ovarian torsion include the patient history and physical exam, bloodwork and urinalysis, diagnostic imaging, provider expertise in conducting sonography, and ultimately access to surgical diagnosis.

Clinical Decision-Making

The research has demonstrated that providers cannot rely on one diagnostic modality to confirm ovarian torsion. Patient history, physical exam, bloodwork and urinalysis results, and imaging findings must be analyzed together to rule out common alternate pathologies and help to rule-in a high suspicion of torsion. From the factors identified that impact diagnosis of ovarian torsion, patient history and physical exam findings compromise necessary steps to assist the clinician in developing differential diagnoses and ruling in or ruling out certain pathologies. A major challenge with clinical diagnosis of ovarian torsion identified in the literature reviewed is the wide spectrum of symptoms and clinical presentation. Providers should not hesitate to quickly involve obstetrics and gynecology (Campo, 2009; Kives, 2017), as surgical via exploration with laparoscopy remains the only definitive way to diagnose and correct ovarian torsion (Kives, 2017).

The following are patient history and physical exam findings that should increase suspicion of ovarian torsion by the clinician: history of prior ovarian torsion, known presence of ovarian cysts (Tabbara et al., 2024; White & Stella, 2005), treatment with ovarian

stimulation from fertility treatments, pregnancy (Tabbara et al., 2024), sudden onset and severe right lower quadrant abdominal pain, nausea and vomiting (Otjen et al., 2014; Shyy et al., 2018; Tabbara et al., 2024; White & Stella, 2005), palpable abdominal mass, and abdominal pain on exam (Kroger-Jarvis et al., 2018; Tabbara et al., 2024; White & Stella, 2005). Although these findings are strongly associated with ovarian torsion, torsion cannot be ruled out in the absence of the above symptoms, therefore strongly associated symptoms should help to confirm clinical suspicion of torsion and not be used to rule out ovarian torsion as a differential diagnosis.

Bloodwork and urinalysis exams should be completed to help to rule out other common pathologies, such as appendicitis, pregnancy complications, or infection. As with the physical exam, bloodwork and urinalysis results cannot effectively rule out ovarian torsion as patients with torsion can present with systemic inflammatory response syndrome signs, such as elevated WBC and fever (Campo, 2009; Tabbara et al., 2024; White & Stella, 2005). Recommendations to complete bloodwork and urinalysis exams have not changed over the last 20 years, as above studies show, and could relate to the rarity of the condition of ovarian torsion and lack of clinically relevant biomarkers for diagnosis.

Use of Diagnostic Imaging

As with patient history and physical exam findings, the review findings suggest that diagnostic imaging should be used to assist clinicians in ruling out other causes of acute abdominal pain and not be used in isolation to rule out ovarian torsion. If a CT scan has already been repeated and shown to be abnormal, the findings suggest that the results not be confirmed with ultrasound as neither are diagnostic for ovarian torsion. The findings are consistent with clinical practice guidelines by the Society of Obstetricians and

Gynaecologists of Canada who recommend that ultrasound with and without colour doppler flow be completed in cases of suspected ovarian torsion, however a decision on whether to proceed to surgery should not be decided based on results of ultrasound alone (Kives et al., 2017).

It appears clinicians have improved over the last 20 years in diagnosing ovarian torsion, and do not entirely rely on ultrasound or CT results to make a diagnosis. Tabbara et al. (2024) reported 20% of cases of ovarian torsion proceeded to the operating room on clinical suspicion alone prior to imaging, and 95% of patients in both the imaging and non-imaging groups in total had ovarian salvage. This is much improved from White & Stella (2005), who only reported a 30.8% ovarian salvage rate, and Cohen et al. (2001b) who reported only a 44% accuracy in pre-operative diagnosis of ovarian torsion, even when imaging was included as part of the work-up. These findings are consistent with the recommendation by the American College of Obstetricians and Gynecologists (2019) that ovarian salvage is preferred unless the organ is obviously necrotic, and tissue is falling apart on visual exam. Research by Novoa et al., (2021) demonstrated in laboratory studies that ovaries removed due to a blue or dusky appearance often do not show evidence of necrosis on biopsy, and therefore aggressive ovarian salvage should be attempted. This is in agreement with other authors, who noted that imaging increases times to surgery and should not cause a delay in care (Tabbara et al., 2024; White & Stella, 2005). In the case report by Shyy et al. (2018), the patient with positive findings of ovarian torsion on CT was brought back to hospital and underwent ultrasound examination prior to surgery, and ultimately required an oophorectomy. It is not possible to determine with certainty, however it is

possible had this delay in care not occurred that ovarian salvage may have been possible for this patient (Shyy et al., 2018).

Limitations of Research Design

Efforts were made to complete a standardized literature search using common search terms; however, it is possible that some research studies which met the inclusion criteria were missed as searches were completed using only MEDLINE and CINAHL databases. It is also possible that some articles were missed which identified key words other than the search terms used.

The location of many studies were in the Middle East (Lebanon and Israel) (Cohen et al., 2001a; Cohen et al., 2001b; Silber et al., 2022; Tabbara et al., 2024) and the United States (Campo, 2009; Otjen et al., 2015; Shyy et al., 2018; Swenson et al., 2014). Israel has universal healthcare coverage for its citizens and residents, while Lebanon and the United States all operate with a combination of publicly funded and privately funded hospitals, without universal healthcare insurance for residents and citizens (Commonwealth Fund, 2020; Nassar et al., 2023). Due to differences in health care delivery and differing healthcare systems, there are some limitations in generalizing the data to the publicly funded Canadian health care system. Lastly, as all but one research study was conducted at a tertiary and/or university-affiliated hospital (Kroger-Jarvis et al., 2018) the results cannot be generalized to include rural or remote emergency departments which may have less access to services such as 24-hour lab, on-site diagnostics, 24-hour surgery capabilities, and limited travel distance for people to access healthcare.

Patient & Provider Impact

Ovarian torsion affects women in their childbearing years, with median age at presentation ranging from 27.3 (Tabbara et al., 2024) to 33.5 years of age (White & Stella, 2005). Rates of ovarian salvage have increased, from 30.8% in 2005 (White & Stella, 2005) to up to 95% in 2024 (Tabbara et al., 2024). Reasons for increased ovarian salvage could be due to increased provider awareness of ovarian torsion, decreased time to surgery, preference to attempt ovarian salvage unless organ is obviously necrotic, or ease of access to healthcare by the patients in the above studies. As there have not been major shifts in methods of diagnostics for ovarian torsion in the last 20 years, it is unlikely the increase in ovarian salvage is due to any singular factor.

Ovarian torsion remains an uncommon and yet significant gynecological emergency for providers to be aware of. If ovarian torsion progresses, it will eventually result in necrosis of the organ leading to oophorectomy and possible sepsis in the affected individual (Kroger-Jarvis et al., 2018). As torsion affects primarily young adults, there is also a significant potential for decrease in fertility if ovarian torsion is missed. Although diagnostic laparoscopy is the only way to definitively diagnose torsion at this time, pre-operative diagnostic accuracy remains poor, at 44% (Cohen et al., 2001b).

Future Possibilities

There is future potential for diagnostic markers, such as serum IL-6, in the diagnosis of ovarian torsion. However, currently research is still in its beginning stages. As mentioned by Naylor et al. (2024), a major set-back at this time is the lack of standardization of studies of IL-6 in ovarian torsion in humans as well as no capability for point of care testing in hospitals. If IL-6 is to be further studied as a potential biomarker in non-invasive detection of

ovarian torsion, larger-scale case control studies in humans would need to be completed to assess if this is a sensitive and specific marker for ovarian torsion.

Computed tomography also showed promise as a diagnostic tool for ovarian torsion, showing both high sensitivity and specificity for detection of torsion. If a patient is showing signs of ovarian torsion on CT scan, additional time should not be taken to obtain a pelvic ultrasound, as this does not increase the diagnostic accuracy and can increase time to operative correction of the torsion (Shyy et al., 2018; Swenson et al., 2014). While ultrasound is preferred to reduce patient exposure to radiation, if a CT has been done prior to an ultrasound, additional imaging should not be repeated. To increase provider comfort with diagnosing ovarian torsion without ultrasound exam, larger-scale retrospective case reviews should be completed to confirm results by Swenson et al. (2014) showing high sensitivity and specificity for CT scan in diagnosis of ovarian torsion.

Relevance to Nurse Practitioners

Nurse practitioners (NPs), both working in the community and in emergency departments, should be aware to keep ovarian torsion on the list of differential diagnoses in women and people with ovaries presenting with severe abdominal pain to their clinic or hospital. Nurse practitioners who work in emergency departments will often be assigned to "fast track" areas, which most often see patients who are of childbearing age and ambulatory (Campo, 2009; Kroger-Jarvis et al., 2018), and therefore may be involved in assessing and diagnosing these patients. If trained in bedside ultrasound, NPs should be mindful of research showing improved diagnostic accuracy when ultrasonography is performed by a training sonographer compared to a bedside procedure (Silber et al., 2022), and order a formal ultrasound when available. If performing a bedside ultrasound, NPs should not use

ultrasound to rule-out the possibility of torsion, but to assess for potential signs of torsion which may assist with escalation to consultation involvement such as ovarian edema, enlarged ovaries, or presence of cysts (Silber et al., 2022). If working in a more rural setting without access to imaging or surgical services, it remains important to have a high index of clinical suspicion for ovarian torsion to facilitate timely transfer to higher levels of care for definitive diagnosis and management.

Conclusion

Ovarian torsion remains a rare and yet serious gynecological emergency that affects females and people with ovaries primarily in their child-bearing years. If not promptly treated and recognized, ovarian torsion can lead to ovary necrosis, sepsis, organ loss, and a reduction in fertility if oophorectomy is required for treatment (Ashmore et al., 2023; Campo, 2009; Tabbara et al., 2024). The definitive treatment for ovarian torsion is surgical correction via laproscopy and detorsion of the affected ovary (S. Cohen et al., 2001; Tabbara et al., 2024; White & Stella, 2005). An integrative review of available data was completed on factors that impact the diagnosis of ovarian torsion in adult non-pregnant women who present to the emergency department. Databases MEDLINE and CINAHL were used to conduct a literature search and a total of 12 articles were analyzed to identify factors that impact the diagnosis of torsion. Data extraction was completed to visualize common themes; patient history and physical exam, bloodwork and urinalysis, diagnostic imaging, provider expertise in sonography, and access to surgical diagnosis and treatment were all identified as factors impacting diagnosis.

Diagnosis of ovarian torsion is multifactorial, and the clinician should use available diagnostic tools primarily to rule out other acute abdominal and gynecological pathologies, as no singular non-invasive diagnostic tool is able to rule-out torsion. A combination of patient history, physical exam, bloodwork, urinalysis, and ultrasound imaging by a trained sonographer should be done as part of the initial work-up (Silber et al., 2022), however imaging should not result in a delay to surgical consultation if suspicion for torsion is high (Campo, 2009). There is the potential for involvement of the biomarker IL-6 in non-invasive diagnosis of ovarian torsion, however currently research is limited to a small number of

studies and there is no direct clinical application of this tool (S. B. Cohen et al., 2001; Naylor et al., 2024). Further research is needed to replicate study results as develop point of care testing for this biomarker.

This study was limited by design; only two databases were searched and therefore useful articles may have been missed in the initial search. Future research opportunities include investigation into other factors that may impact diagnosis of ovarian torsion, such as clinician experience level and additional education. Other research potential includes factors that impact time from suspected diagnosis to surgery, and research into how being situated in a rural site may impact diagnosis and ovarian torsion correction. In summary, the diagnosis of ovarian torsion remains clinically challenging, with diagnosis involving the intersection of patient history, physical exam, and imaging findings. Failure to recognize ovarian torsion can result in clinical deterioration as well as loss of the ovary. Clinicians should exercise a high degree of suspicion for ovarian torsion in patients presenting with an acute abdomen for which another cause is not obviously apparent.

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Appendix A

MEDLINE Search Strategy (via EBSCO)

Search ID#	Search Terms	Search Options	Actions
S15	S10 AND S13 not preg* not ped*	**Expanders** - Apply equivalent subjects **Search modes** - Find all my search terms	View Results (52) View Details Edit
S14	S10 AND S13	**Expanders** - Apply equivalent subjects **Search modes** - Find all my search terms	View Results (129) View Details Edit
S13	S11 AND S12	**Expanders** - Apply equivalent subjects **Search modes** - Find all my search terms	View Results (11,224,421) View Details Edit
S12	adult* or female* or woman or women	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S11	(MH "Adult") or (MH "Women") or (MH "Female")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S10	S5 AND S6 AND S9	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S9	S7 OR S8	**Expanders** - Apply equivalent subjects **Search modes** -	Rerun View Details Edit
S8	clinical diagnosis or diagnosis or finding	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S7	(MH "Diagnostic Techniques and Procedures") OR (MH "Diagnosis")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S6	S3 OR S4	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S5	S1 OR S2	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S4	emergency department OR ed OR a&e or accident and emergency or emergency room or er	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S3	(MH "Emergency Service, Hospital")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S2	ovarian torsion OR adnexal torsion	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S1	(MH "Ovarian Torsion")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit

Appendix B

CINAHL Search Strategy (via EBSCO)

Search ID#	Search Terms	Search Options	Actions
S14	S10 AND S13	**Expanders** - Apply equivalent subjects **Search modes** - Find all my search terms	View Results (35) View Details Edit
S13	S11 AND S12	**Expanders** - Apply equivalent subjects **Search modes** - Find all my search terms	Rerun View Details Edit
S12	adult* or female* or woman or women	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S11	(MH "Adult") or (MH "Women") or (MH "Female")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S10	S5 AND S6 AND S9	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S9	S7 OR S8	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S8	clinical diagnosis or diagnosis or finding	**Expanders** - Apply equivalent subjects **Search modes** -	Rerun View Details Edit
S7	(MH "Diagnostic Techniques and Procedures") OR (MH "Diagnosis")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S6	S3 OR S4	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S5	S1 OR S2	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S4	emergency department OR ed OR a&e or accident and emergency or emergency room or er	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S3	(MH "Emergency Service, Hospital")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S2	ovarian torsion OR adnexal torsion	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit
S1	(MH "Ovarian Torsion")	**Expanders** - Apply equivalent subjects **Search modes** - Proximity	Rerun View Details Edit

Appendix C

Data Extraction Tables

Article Number	1			
Author(s)	Kroger-Jarvis et al.			
Article Title	Ovarian Torsion: ED Recognition and Management			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Early recognition of ovarian torsion	Case Report	Small community hospital emergency department, specific location not specified	- Absence of pain and tenderness does not rule out ovarian torsion - Bimanual exam may or may not confirm pelvic mass - Bloodwork and urinalysis can help exclude other differential diagnoses (appendicitis, cystitis, diverticulitis, ectopic pregnancy, etc) - sensitivity of u/s is 46-75% - CT scan should only be used to exclude other diagnoses - ovarian mass is most common risk factor, occurs in 86-95% of cases (>5cm mass most common) - detorsion is preferred over salpingo-oophorectomy	- Access to imaging (ultrasound, CT), lab, surgical consultation (OBGYN)

Article Number	2			
Author(s)	Tabbara et al.			
Article Title	Ovarian Torsion: A retrospective case series at a tertiary care center emergency department			
Study Question/ Phenomena of Interest	**Type of Study/Participants**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Clinical presentation, physical examination, emergency management, time-to-intervention metrics of ovarian torsion patients presenting to the emergency department	Retrospective case series 20 participants Retrospective chart review over 1 year, Jan 1, 2019 – Dec 31, 2019	Emergency department of large tertiary hospital, urban center (Beirut, Lebanon)	- Incidence of torsion was 157.4 per 100,000 visits of women in reproductive age group (very rare) - 78.9% presented within 24 hours of symptom onset - 80% underwent u/s - 20% direct to OR based on clinical suspicion - abnormal ovarian blood flow detected in 50% of u/s cases, 75% had ovarian cysts/masses, 68.9% showed ovarian edema - 31.3% had abnormal ovarian location on u/s - more common on R ovary (60% vs 40%) - 19/20 patients had ovarian preservation after surgery - mean door to ultrasound = 1.4hrs, mean door to surgery = 11.4hrs - physical findings: abdominal pain (95%) (severe), RLQ pain, N/V, abdominal tenderness on exam (65%) - 95% of patients required opioids to control pain - 1 patient had non-salvageable ovary: had >72 hours of pain prior to presentation	- Access to timely ultrasound (mean time was 1.4 hours); authors suggest point of care ultrasound - Access to timely surgery (mean time was 11.4 hours) - Patient history (RLQ abdominal pain, severe, N/V, risk factors such as known cysts) - Provider expertise/experience

Article Number	3			
Author(s)	Cohen et al.			
Article Title	The accuracy of serum interleukin-6 and tumor necrosis factor as markers for ovarian torsion			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Investigate role for interleukin-6 (IL-6) and tumour necrosis factor (TNF-alpha) as pre-operative markers for the diagnosis of ovarian torsion	Prospective case series 20 participants total Recruited from January 1998 – December 1999	Patients admitted to gynecological emergency room All had pre-operative diagnosis of ovarian torsion Sheba Medical Center (Tel Aviv, Israel) Urban center, university-affiliated hospital	- Only 40% of patients had ovarian torsion confirmed during surgery - Surgical diagnosis of remaining 12 patients was ovarian cyst - 6 of 8 patients with ovarian torsion had elevated serum IL-6 - none of the 12 patients without torsion had elevated serum IL-6 - no difference between groups in serum TNF-alpha	- Clinical diagnosis is often poor (40% in this study) - Gold standard remains diagnostic laparoscopy - Not thoroughly examined in this study due to study design - Authors note that study limited by small sample size - Results would need to be repeated with larger cohort of patients

Article Number	4			
Author(s)	Cohen et al.			
Article Title	Accuracy of the preoperative diagnosis in 100 emergency laparoscopies performed due to acute abdomen in nonpregnant women			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
The accuracy of preoperative diagnosis in non-pregnant women coming to the emergency room with acute abdomen in relation to diagnoses made during emergency laparoscopy	Retrospective case series 100 consecutive non-pregnant women of reproductive age (1997-1999)	Unclear where study site was, only states "university-affiliated hospital" Study authors are in Tel-Aviv Israel, can assume study completed in this location	-Preoperative diagnosis was ovarian torsion in 66 patients (66%) -Intraoperatively, torsion was present in 29 patients (44%) -most common surgical finding in patients clinically diagnosed with torsion who did not have torsion surgically was ovarian cysts (54.5%), adhesions (20.5%), and bleeding corpus luteum (13.6%) -10% of patients had post op complications (fever, wound seroma, and required laparotomy) -authors note that use of ultrasound can help confirm torsion preoperatively but cannot rule out -missed diagnosis of torsion can result in subsequent malpractice litigation (may explain large # of laparoscopies performed) -noninvasive diagnosis remains challenging -patients should be well informed of possibility of incorrect diagnosis	-Preoperative diagnosis by clinician -Access to emergency laparoscopy -Potential fear of litigation

Article Number	5			
Author(s)	White & Stella			
Article Title	Ovarian torsion: 10-year perspective			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Describe presenting features and diagnostic approach to ovarian torsion over 10-year period, and offer suggestions for optimal investigation and management of these patients in the emergency department	Retrospective case series 52 cases total May 1990-2000	Royal Women's Hospital in Melbourne, Australia Tertiary hospital Surgically proven ovarian torsion	-Median age 33.5 years -R adnexal torsion in 55.8% of patients -30.8% with recognized risk factors (history of torsion, cysts, tubal ligation, ovarian hyperstimulation syndrome, polycystic ovarian syndrome) -median time from symptom onset to ED presentation was 3 days -palpable abdominal mass in 62.2% -N/V in 59% -ovarian torsion clinically suspected in 19.2% of patients, confirmed by ultrasound in additional 11.5% -all ultrasound reports were abnormal (cysts, free fluid in pelvis, etc) -time to diagnosis affected ovarian preservation (12hr vs 22.5hr for no ovarian preservation)	-ultrasound delayed time to diagnosis (9hr vs 24hr), however ultrasound was abnormal in all patients with torsion -difficult to diagnose both clinically and with imaging -patients with risk factors for torsion were diagnosed more quickly (12hr vs 26hr)

Article Number	6			
Author(s)	Silber et al.			
Article Title	Accurate diagnosis of adnexal torsion – not only for expert sonographers			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Evaluate clinical and sonographic parameters that are associated with a correct or incorrect diagnosis of ovarian torsion by OBGYN resident or attending physicians compared to expert sonographers	Retrospective case series 118 cases total 2010-2019	Tertiary hospital University-affiliated medical center Women presenting to the emergency department with acute lower abdominal pain who were subsequently diagnosed laparoscopically with ovarian torsion Study authors are in Tel-Aviv Israel, can assume study completed in this location	-64.4% diagnosed correctly from ED assessment (1st ultrasound) -33.1% pregnant (majority in first trimester) -correctly diagnosed group had more complaints of vomiting -no difference in accuracy on different shift times (day vs evening vs night) -more sonograhic parameters were used in the evaluation of the correctly diagnosed patients (size of ovary and ovarian edema specifically) -ovarian cysts were more frequently found in incorrectly diagnosed group -expert sonographers used significantly more sonographic parameters (size of normal vs pathological ovary, absence/presence of doppler flow, ovarian edema, whirlpool sign) -when looking at same parameters, expert sonographers were more successful at identifying edema and abnormal doppler flow	-Access to expert sonographer -Subjective clinical impression of the primary clinician who examines the patient (can affect the speed of the assessment) -Patient complaint of abrupt abdominal pain followed by vomiting led to more clinician suspicion for torsion

Article Number	7			
Author(s)	Otjen et al.			
Article Title	A normal ovary in an abnormal location: A case of torsion			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Case of torsion presented focusing on sonographic appearance of medialized ovary only	Case Report 1 case	18-year-old female Presented to freestanding quaternary children's hospital Study authors are located at Seattle Children's Hospital, USA	-right ovary medially positioned, posterior to uterus (different from prior ultrasound showing right ovary in normal position) -both ovaries had normal doppler flow -no imaging finding can exclude ovarian torsion -must take imaging finding in context with history, physical, laboratory findings	-patient had a prior ultrasound imaging done that was normal (3 years prior)

Article Number	8			
Author(s)	Shyy et al.			
Article Title	Right lower quadrant abdominal pain: Do not forget about ovarian torsion on the computed tomography scan			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Case presentation of ovarian torsion on CT that was missed on preliminary report	Case Report 1 case	25-year-old-female San Francisco General Hospital, USA Large urban center	-patient had history of ulcerative colitis and systemic lupus erythematosus -RLQ tenderness on exam -3.9cm cyst on right ovary was present on initial CT report, patient was discharged with outpatient pelvic ultrasound requisition -CT was re-read next day by attending radiologist and concern noted for ovarian torsion -radiologist recommended confirmation with doppler ultrasound, which was done	-human error -patient history: patient stated pain felt like ulcerative colitis flares -CT was re-read and patient was called back to hospital -repeat imaging was done after CT (ultrasound) -patient ultimately needed partial oopherectomy

Article Number	9			
Author(s)	Campo, T.			
Article Title	Ovarian torsion in a 23-year-old female with pelvic pain			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
To help providers gain a more thorough understanding of and have a heightened suspicion for patients with ovarian torsion	Case Report 1 case	23-year-old female Nurse Practitioner-authored Location not available, in USA	-presenting complaint: sudden, sharp LLQ pain -patient stated she had history of ovarian cysts -differential is broad; complete urinalysis and urine pregnancy test, bloodwork, and imaging to assist in diagnosis -opioids should not be withheld -fever, peritoneal signs, and elevated white blood cell count are usually late signs (signs of necrosis)	-patient presented to ER quickly after pain started -clinician suspicion for torsion -ultrasound was positive for torsion -STAT OBGYN consultation and surgery was organized -patient had ovarian salvage

Article Number	10			
Author(s)	Swenson et al.			
Article Title	Ovarian torsion: Case-control study comparing the sensitivity and specificity of ultrasonography and computed tomography for diagnosis in the emergency department			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Compare the diagnostic performance of pelvic ultrasound and CT in women presenting to the ED with acute lower abdominal pain/pelvic pain related to ovarian torsion	Retrospective case-control study 20 cases total of ovarian torsion + 20 randomly selected, age-matched control patients Radiologists blinded to patients, aware that study was to evaluate imaging findings of ovarian torsion March 1, 2005-July 31, 2010	Multicenter study 2 urban hospitals Locations not available, in USA	-2 radiologists reviewed all CT and U/S -pelvic U/S 80% sensitive and 85-95% specific for torsion -CT was 90-100% sensitive and 85-90% specific for torsion -radiologist most reported U/S as falsely negative when cysts were present -presence of abnormal ovary on CT must be consider suspicious for torsion -results contradict common thinking that U/S is superior to detect torsion	-human error/false reading of CT or ultrasound (difficulty of interpreting ultrasound when cysts present or falsely attributing large ovary size to cysts)

Article Number	11			
Author(s)	Christopoulos et al.			
Article Title	Interleukin-6 for the diagnosis of ovarian torsion: A systematic review and meta-analysis			
Study Question/ Phenomena of Interest	**Type of Study/Methods (inc # of participants)**	**Context-related info (location urban vs rural, size of study site)**	**Results/Themes from study**	**Factors that impacted recognition of torsion**
Are serum interleukin-6 levels a helpful diagnostic test in cases of ovarian torsion?	Systematic Review 3 studies met inclusion criteria, total of 70 cases	Not applicable	-no standardized cut off value for elevated IL-6 -85.7% sensitive and 84.1% specific for ovarian torsion -only patients who had ultrasound evidence of a cyst >5cm were included	-N/A to this study -interleukin-6 (IL-6) point of care testing is not available -poor external validity

Appendix D

Critical Appraisal of Research Articles

Scoring

Low trustworthiness/relevance of results 1 --> 2 --> 3 --> 4 --> 5 High trustworthiness/relevance of results

Article Author(s) & Title of Article	**Methods/selection of subjects clearly documented?**	**Limitations**	**Comments**	**Overall Score of Article**
Kroger-Jarvis et al. (2018) *Ovarian torsion: ED recognition and management*	Unclear - Specific location of site, urban/rural not documented	Case Report limits external validity	Case Report is limiting as cannot be extrapolated to general population (not representative sample)	3
Tabbara et al. (2024) *Ovarian torsion: A retrospective case series at a tertiary care center emergency department*	Yes	1 center study - urban area	Time from patient presentation to ultrasound is much less than other studies – authors do not comment if this is bedside vs. formal ultrasound	5
Cohen et al. (2001a) *The accuracy of serum interleukin-6 and tumor necrosis factor as markers for ovarian torsion*	Yes	Very small sample size (8 with torsion)	External validity low as markers examined not able to be measured in real-time	4
Cohen et al. (2001b) *Accuracy of the preoperative diagnosis in*	Unclear – Do not state specific	Likely 1 center study – urban area	Good external validity to urban environments as retrospective case	5

100 emergency laparoscopies performed due to acute abdomen in nonpregnant women	location, only authors' hospital affiliation		series decreases bias, participants chosen consecutively	
White & Stella (2005) *Ovarian torsion: 10-year perspective*	Yes	Retrospective nature and only including surgically proven ovarian torsion may have missed some patients who had a delayed and/or initial missed diagnosis	10-year-study is advantageous Authors note that ultrasound was 'abnormal' in all patients with torsion, but also comment ultrasound delayed diagnosis	5
Silber et al. (2022) *Accurate diagnosis of adnexal torsion – not only for expert sonographers*	Yes	Do not state specific hospital involved, or location, only 'university-affiliated medical center'; makes assessment of external validity more challenging	9-year-study led to larger sample size than many other articles Used both resident and attending physicians compared to sonographer – possibly not equivalent in skillset	4
Otjen et al. (2014) *A normal ovary in an abnormal location: A case of torsion*	Yes	Case Report limits external validity	Article included as it demonstrated abnormal location of ovary could increase clinician suspicion of torsion	3
Shyy et al. (2018) *Right lower quadrant abdominal pain: Do not forget about ovarian torsion on the computed tomography scan*	Yes	Case Report limits external validity	Article included as it demonstrated clinical anchoring on previous diagnoses can affect diagnostic reasoning, demonstrates human error is a factor in diagnosis	3
Campo, T (2009) *Ovarian torsion in a 23-year-old female with pelvic pain*	Yes	Case Report limits external validity	Thoroughly discusses initial presentation, work-up, diagnosis, and discharge disposition of patient	3

Swenson et al. (2014) *Ovarian torsion: Case-control study comparing the sensitivity and specificity of ultrasonography and computed tomography for diagnosis in the emergency department*	Unclear – not discussed how radiologists were chosen to read images Does note radiologists were blinded to patient conditions, but were aware study was evaluating ovarian torsion	Only 2 radiologists reviewing images Small sample size – 20 control and 20 affected	Study could have been strengthened if larger number of radiologists were reviewing images, would have strengthened overall conclusions of article	4
Christopoulos et al. (2013) *Interleukin-6 for the diagnosis of ovarian torsion: A systematic review and meta-analysis*	Yes	Small amount of research done on IL-6 and ovarian torsion, only 3 studies for evaluation in total.	More research needed to apply clinically	4
Naylor et al. (2024)	Yes	Very broad inclusion criteria, unable to generalize results as animal and human models studied. Comparison of results between studies with differing methodology. Animal versus human model comparison not valid due to such broad differences in subjects. Animal data not included in this review.	Most recent and most thorough meta-analysis of research. More research needed on human subjects with standardized IL-6 cut-off values needed. Standardization of participant selection/enrolment.	3