



## Review article

## The multidisciplinary approach to ovarian tumours in children and adolescents

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## ABSTRACT

Ovarian tumours in children and adolescents are rare diseases. Although the majority of tumours are benign, the diagnosis and management present various challenges that require a wide range of expertise. The multidisciplinary team ensures not only accurate diagnosis and correct and minimally invasive management, but also minimal psychological impact and the preservation of fertility. This article outlines the multidisciplinary team approach to ovarian masses in children and adolescents. The team includes paediatric oncologists, gynaecological surgeons, pathologists, radiologists, fertility experts, geneticists and psycho-social services.

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## Introduction

Paediatric ovarian tumours are rare disorders with a crude incidence rate of 2.6–3/100 000 girls per year [1]. The clinical presentation varies according to age groups and differs from adults. In children most tumours are benign with approximately 30% of tumours being malignant [2]. Ovarian malignancies constitute less than 3% of all childhood malignancies [1]. In both children and adolescents anatomical and physiological processes can be dysregulated in the presence of ovarian tumours [3]. The heterogeneous presentation and variable aetiologies necessitate a coordinated multidisciplinary team approach. Management should be curative, function sparing, minimally invasive and sensitive to the psycho-emotional impact on this vulnerable population. The aim of this article was to evaluate the most important considerations in a child with an ovarian tumour.

## Methodology

A comprehensive literature review of publications on Pubmed, Medline, Global Health, Embase, ScieLo and Google Scholar with medical subject headings in keeping with pelvic tumours in children and adolescents were done. Articles were limited to English language articles or conference abstracts after 1995. Articles or studies with more than 5 patients were included. The aim was to evaluate the multidisciplinary team in the management of pelvic tumours in children. Limited articles described the management beyond the biological aspects. Supplemental references were sought to support or elaborate on article findings. Therefore, the important themes are discussed as a descriptive article. The flow diagrams and tables were constructed for descriptive purposes.

## History

The patient history guides the initial differential diagnosis and investigational strategy [3]. At first contact the management trajectory of a patient by the multidisciplinary team is established and complements the diagnostic and management process.

### Adolescent health

During the primary interview with adolescents, basic age-related information is important and includes the history

regarding menstrual habits related to menarche, volumes and dysmenorrhea. The interview must be conducted in a secure environment in a non-threatening and non-judgemental way [4]. Only selected persons should be present, importantly those relating to the support of the child and medical personnel vital to obtaining consent and in the management of the tumour [5].

Establishing the sexual history indicates if trans-vaginal examinations are possible and pregnancy tests should be performed before any interventions or treatment is done. It is advisable to include a pregnancy test for documentation purposes, regardless of the history. The increased risk for sexually transmitted diseases associated with sexual contact should be determined [3].

### Inheritance patterns

Most ovarian tumours are due to somatic mutations caused by factors acquired during a patient's lifetime. Inherited predispositions or germline mutations follow an autosomal dominant pattern and stem from both the maternal and paternal lineages [6].

### Family and genetic history (see Table 1)

Screening for ovarian tumours in asymptomatic children and adolescents is not advised. A lower threshold for screening patients may be dictated by family and genetic information suggestive of a predisposition to ovarian tumours. The history of first-order relatives remains the most important predictor for ovarian malignancies. This is true especially if the history is from the paternal lineage [6]. Although a bi-directional relationship exists between ovarian tumours in adolescence and childhood and cancer predisposition syndromes, they are very rare. Mucinous epithelial malignancies and, to a larger degree, non-epithelial malignancies form the majority of this group. Dicer-1 syndrome, rhabdoid predisposition syndrome type 2 and Peutz-Jeghers syndrome have the highest association with ovarian pathology [7], whereas juvenile granulosa cell tumours are specifically associated with Ollier and Marfucci syndromes [8]. Table 1 illustrates cancer predisposition and ovarian tumour associated syndromes with their distinguishing clinical features. Meigs' syndrome is defined as the presence of ascites and/or hydrothorax in association with a benign ovarian tumour. In this syndrome the tumours are commonly leiomyomas and fibromas [9,10].

**Table 1**  
Predisposition syndromes.

Prevalence	1/3	2/3
<b>Grade</b>	Low grade/borderline	High grade
<b>Mutations</b>	MMR SMARCA4 PTEN, KRAS, BRAF, PIK3CA, ERBB2, CTNNB1, ARID1A PPP2R1A,	BRCA1/BRCA2 TP53 DICER1
<b>Types of mutation</b>	Somatic	Germline Somatic
<b>Syndromes</b>	Lynch syndrome Gorlin syndrome	Li-Fraumeni syndrome Ollier syndrome Marfucci syndrome
<b>Clinical Origin</b>	Cystic or confined to ovary	Aggressive or metastatic disease Fallopian tube histology related ovarian pathology associated with TP53 [11]

**Clinical pathology**

Pathological processes can occur along embryonal remnants, ectopic tissue and the ovaries [12]. The three main cell types of ovaries are responsible for diverse pathology. The coelomic epithelium gives rise to epithelial malignancies, whereas the stromal layer is responsible for gonadal stromal tumours [12]. Germ cell tumours originate within the primordial germ cells that migrate from yolk sac to gonads early in the development [1,13]. Various other pathologies are related to aetiology rather than histology [14]. Diagram 1 illustrates a clinical approach to the differential diagnoses with regard to anatomy and pathology.

**Age**

During the prepubertal age, tumours are mainly of germ cell origin, including teratomas and dysgerminomas. Over 60% of tumours occurring in post pubertal ages are mainly epithelial neoplasms, with the most aggressive forms prevalent with increasing age into adulthood [15]. Although not limited to these values, the incidence of tumours increases from the age of 8–9 years with a peak at 18 years of age [15]. Germ cell tumours characteristically present at the ages of 2–5 years of age [16] (see Table 2).

**Symptomatology**

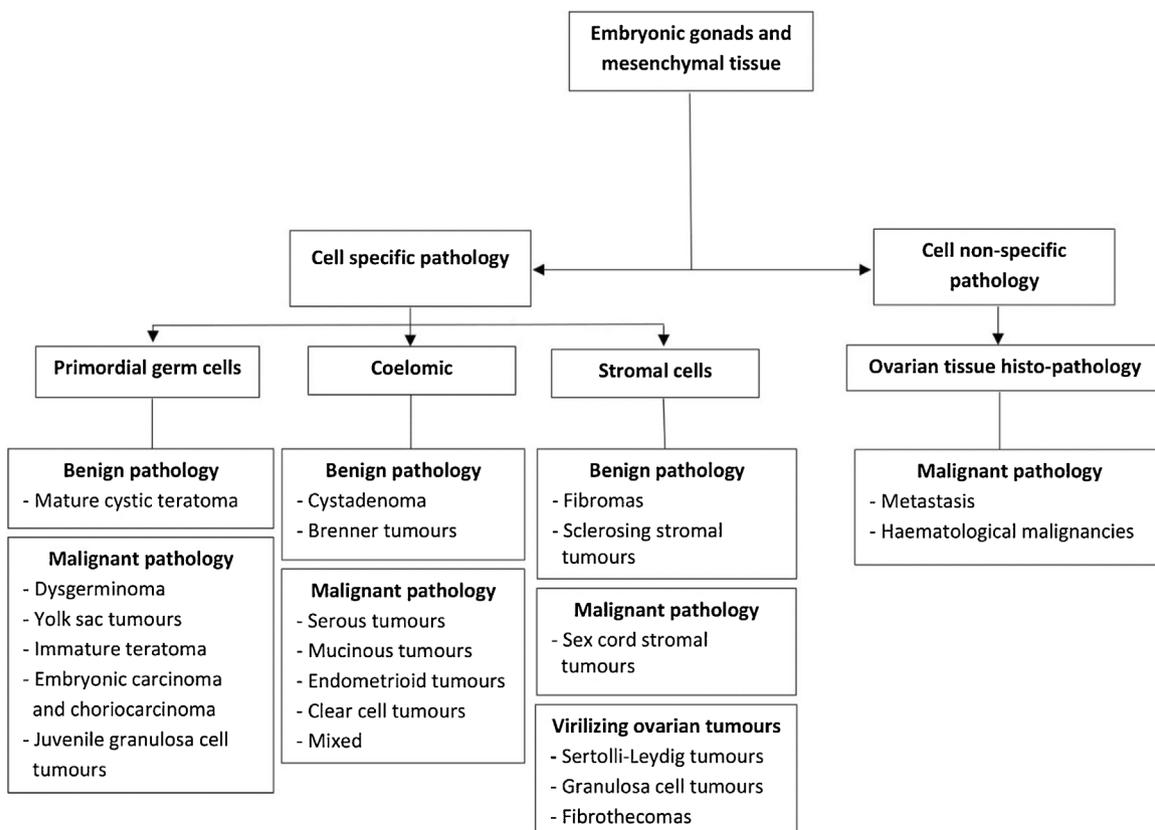
Symptoms correlate to the initial size and pathology, but not with the malignant potential of the tumour [17]. A patient could be asymptomatic or present with general non-specific general symptoms such as fatigue, fever and loss of weight. A high index of suspicion for malignant disease and progressive disease is prudent, especially with increasing symptoms and

**Table 2**  
Age-related pathology.

<b>Germ cell tumours</b>	
Mature cystic teratoma	6–20yrs
Immature teratoma	6–20yrs
Embryonal carcinoma	10–20yrs
Yolk sac tumour	10–30yrs
Dysgerminoma	15–19yrs
<b>Sex cord stromal tumours</b>	
Juvenile granulosa cell tumours	<30yrs
Sclerosing stromal tumour	<30yrs
Sertoli-Leydig cell tumour	<30yrs
Thecoma-fibroma	>30yrs
<b>Epithelial tumours</b>	
<b>Gonadoblastoma</b>	<20yrs
<b>Lymphoma or leukaemia</b>	10–30yrs
<b>Benign pathology</b>	Any age
Meigs' syndrome	From prepuberty

treatment-refractory clinical presentations [17]. In children the primary features are due to hormonal dysregulation, most often precocious puberty. Virilization, precocious puberty and hirsutism are present with hormone secreting masses such as Leydig cell tumours producing male sex hormones. Up to 30% of ovarian masses can present with signs of precocious puberty [2]. Sex cord stromal tumours can produce excess oestrogen resulting in precocious puberty, menstrual abnormalities, endometrial pathology or fibrocystic breast disease [18,19].

Secondary symptoms due to obstruction such as analgesia resistant pain, urinary urgency, frequency and incontinence may develop in relation to the mass effect on the urinary tract system [17]. Bloating, constipation, nausea and vomiting is associated in adolescents and adults as well as dyspareunia in sexually active individuals [17]. Symptoms of paraneoplastic syndromes can be



**Diagram 1.** A clinical approach to the histo-pathology of ovarian tumours.

present before the primary ovarian symptomatology. These systemic effects are associated with the tumour and not due a direct effect of local tumours or metastases, but an auto-immune, hormonal or endocrine nature [20]. In children these syndromes mainly include nervous system disorders, connective tissue disorders and hematologic disorders, but can also include cutaneous disorders and nephrotic syndrome [20]. Neurologic presentations are frequently described in relation to ovarian disease and range from general non-specific symptoms to focal signs and behavioural changes. In the presence of unexplained symptomatology, further diagnostics should be done to identify local disease [21].

## Radiology

The clinical presentation, tumour markers and radiological imaging contribute the most valuable differential information for diagnosis and subsequent treatment [1]. As the pathology in the paediatric and adolescent populations are notably distinct from that of adult populations, the interpretation of imaging by radiologists plays a vital role in setting up the differential diagnoses [1]. During the diagnostic evaluation the essential information for management comprises the anatomical location, the consistency, the possible pathological nature and the proximity to vital structures [1,22]. Abdominal ultrasonography is the primary choice of imaging for screening, but CT-scan or MRI is important for peri-surgical planning.

The importance of imaging is to distinguish between potential benign or malignant tumours (see Table 3) [23,24].

In general, most virilizing tumours are solid, well circumscribed, and without metastasis, ascites and calcifications. Cystic variance is associated with granulosa cell tumours. Macroscopic morphological identification might prove difficult as some tumours present as small masses [18]. The Simple IOTA ultrasound rules include increased blood flow compared to minimal or no blood flow in the mass as a malignant feature [25].

## Ascitic fluid

Ascites, either as an exudate or as a transudate, can be a presenting sign of ovarian pathology and is present in approximately a third of patients [2,26]. Ascites is not limited to malignant tumours but can be associated with benign tumours such as fibromas [10,27]. Many speculative theories exist regarding the production of ascites in the presence of ovarian tumours. These include peritoneal irritability by the primary or metastatic tumours, obstructed lymphatic flow and absorption patterns, increased tumour ascites production and inflammatory cytokine stimulation often seen in the presence of tumours [28].

A combination of tumour markers and cytology on ascetic fluid can be diagnostic for ovarian tumours with a sensitivity of up to 90%, specificity of up to 96.5%, positive predictive values of 85.7%, and a negative predictive value of 97.6% [26,29]. The diagnostic significance of ascitic fluid is supported by the accurate correlation between tumour markers in the blood and ascetic fluid [30]. Post

therapy determination of tumour markers in ascetic fluid has been described, but is limited by the absence of ascetic fluid due to treatment. Applying the triad model of diagnostics in malignancies, the presence of ascites and increased tumour markers in the presence of a mass has a high sensitivity for malignant potential, yet definitive pathology to confirm the diagnosis is still important [30].

Direct visualization of pathogenic cells in ascetic fluid may serve as primary diagnostic medium where a biopsy is not be feasible. Increased leucocytes and proteins are associated with the presence of a malignancy [30,31]. In high malignant potential tumours, and to a lesser degree in low malignant potential tumours, positive cytological findings in ascetic fluid are related to pathology, stage and prognosis [26]. Non-ovarian malignancies, such as gastro-intestinal tumours or Krukenberg tumours, with distinguishing signet-ring cells, can also be distinguished through direct visualization and staining techniques. Genetic mutations and deletions, such as loss of heterozygosity and p53 mutations, can also be determined with the help of ascetic fluid [31].

In the rare cases where a haematological malignancy is suspected, flowcytometry plays a major role in the determination of the diagnosis. Ovaries contain B- and T-cell lymphocytic lineages within cortical granulomas, and rare lymphocytes are present in the ovarian stroma, follicles and corpora lutea [32,33]. Therefore, ovaries are potential organs for primary haematological malignancies. Although it has been reported that up to 1.5–2% of adult ovarian malignancies are of primary haematological origin, the incidence in children and adolescents is low [32,33]. The most common lymphomas of the ovaries in children are Burkitt's lymphoma or Burkitt-like lymphoma [32,33].

For both haematological and non-haematological malignancies, determining the presence of malignant cells in the ascetic fluid has implications for staging, and thus for treatment. In the absence of overt ascites pre-operatively, an intra-operative peritoneal fluid sample with malignant cells upstages patients to IC and IIC classification according to the FIGO staging. This has significant risk classification and treatment implications. The principle of upstaging and increased treatment intensity applies to haematological tumours, such as Burkitt's lymphoma, in the presence of malignant ascites [32,33].

## Tumour markers

### Role of tumour markers

Tumour markers, especially in blood and ascites, are essential pre-operative diagnostics of ovarian tumours to delineate between benign and malignant lesions (see Table 4) [1]. These biomedical markers are products of tumours or responses by the host. They serve as confirmation of the presence, pathological nature or malignant potential of the tumour. The level can contribute to identifying the secretory quality of a tumour, prognostication in the case of malignant germ cell tumours, and the long-term screening for relapse potential [34].

Although certain non-specific markers indicate the possibility of a malignancy, they have limited diagnostic specificity, whilst some specific markers should be evaluated against age-related values. These limitations do not disqualify the essential contribution of these markers with regard to clinical symptoms and imaging in management [34,35].

### Ovarian associated tumour markers

#### Interpretation of tumour markers

Various factors influence the evaluation of results, including age, anatomical site, histology and clinical stage of tumours. Yet tumour markers are validated, non-invasive tests with significant

**Table 3**  
Radiological features of ovarian tumours.

Radiological information	Benign	Malignant
Size	<10 cm	>10 cm
Locality	Single lesion Unilateral	Multiple lesions Bilateral
Consistency	Cystic Homogenous	Solid Heterogeneous
Shape	Well circumscribed	Invasive or metastatic
Calcifications	Not present	Present
Ascites	Generally, not present	Generally present

**Table 4**  
Tumour markers.

Tumour marker	Malignant diagnosis	Non-ovarian malignancy	Non-malignant variability
<b>Alpha fetoprotein (AFP)</b>	Yolk sac tumour Immature teratoma Embryonal carcinoma Sertoli-Leydig cell tumour (rare)	Hepatoblastoma Hepatocellular carcinoma	Physiological variability Liver disease
<b>Beta-human chorionic gonadotropin (<math>\beta</math>-hCG)</b>	Choriocarcinoma Embryonal carcinoma Dysgerminoma (rare)	Down syndrome	Physiological variability
<b>Lactate dehydrogenase (LDH)</b>	Dysgerminoma	Haematological malignancies Abdominal malignancies	Haemolysis Various tissue pathologies and necrosis
<b>CA-125</b>	Epithelial tumours	Bone tumours Breast cancer Endometrial malignancy	Benign breast disease Endometriosis Liver disease
<b>Inhibin A Calcium (Ca<sup>++</sup>)</b>	Granulosa cell tumour Sex cord stromal tumours	Bone tumours Rhabdoid tumours	Parathyroid disease
<b>Human epididymis protein 4 (HE4)</b>	Malignant and borderline epithelial ovarian tumours	Non-small and small cell lung cancer	Cystic fibrosis

sensitivities and specificities that aid the diagnosis, prognostication and therapeutic monitoring of childhood malignancies [36]. LDH, AFP and  $\beta$ -hCG have been established as the most reliable markers in the classification of germ cell tumours in low, intermediate and high-risk groups. LDH has proven invaluable in the diagnosis of both nodal and extra-nodal haematological malignancy and as a measure of the degree of haemolysis of tumour bulk [35].

The absence of tumour markers do not exclude malignancies, as only about 50% malignant tumours present with raised values. Both the histological differences in different age groups and the genetic profile of tumours contribute to the complexity of interpreting results [37]. Hormone profiles change during normal development from a neonate to puberty and physiological values as well as the relevant isoforms of hormones varies.

#### Karyotyping

Chromosomal rearrangements aid in the determination of pathology subtypes, the identification in the activation of oncogenes, predisposition in developing of drug resistance and loss of tumour suppressor gene function [38].

#### Planning of management

The preservation of fertility and reproductive potential is paramount whilst applying the standard of care with the least morbidity [39,40]. All patients with a risk to reproductive potential during surgical interventions and administration of chemotherapy and radiotherapy should be counselled by a fertility specialist to discuss preservation options. Fertility can be preserved by various techniques, which should be discussed with the patient and caretakers prior to interventions that may be harmful to fertility [39,40]. The two main procedures for preservation are: oocyte cryopreservation and ovarian tissue cryopreservation with pregnancy rates varying between 4–60%. Ovarian tissue cryopreservation is the only viable option for prepubertal patients, whilst oocyte cryopreservation should only be offered in patients where treatment delays are possible as it requires ovarian stimulation before oocyte harvesting [39,40].

#### Role of pathologist and haematologist

Various body fluids, such as effusions or ascites, that are obtainable from less invasive techniques, such as punctures, should be aspirated for cytological evaluations or flow cytometry. A

definitive diagnosis may prevent further invasive sampling. This may impose limitations on further biological testing.

Obtaining a frozen section during operative procedures may assist in navigating the extent of operative procedures by distinguishing between benign and malignant lesions [41,42].

A pre-operative discussion with both the pathologist and haematologist may assist in determining the amount of sampling needed for accurate diagnosis and the request of further biological tests to aid diagnosis.

#### Surgical interventions

The final step after a careful multidisciplinary preparation for an ovarian tumour is surgery with a frozen section to aid in diagnostics. The aim is to decide on a surgical approach that is congruent with the expected pathology. A mass should be excised intact to avoid the spilling of potential malignancy cells. The approach is not only taken for therapeutic reasons but also to enable further diagnostics related to staging and direct visualization of abdominal structures (see Diagram 2) [43]. The main considerations remain the potential diagnosis that indicated the procedure, objectives during the intervention, preventing comorbidities, preserving fertility and, but not primarily, the aesthetics of the incision, especially in adolescent females [43].

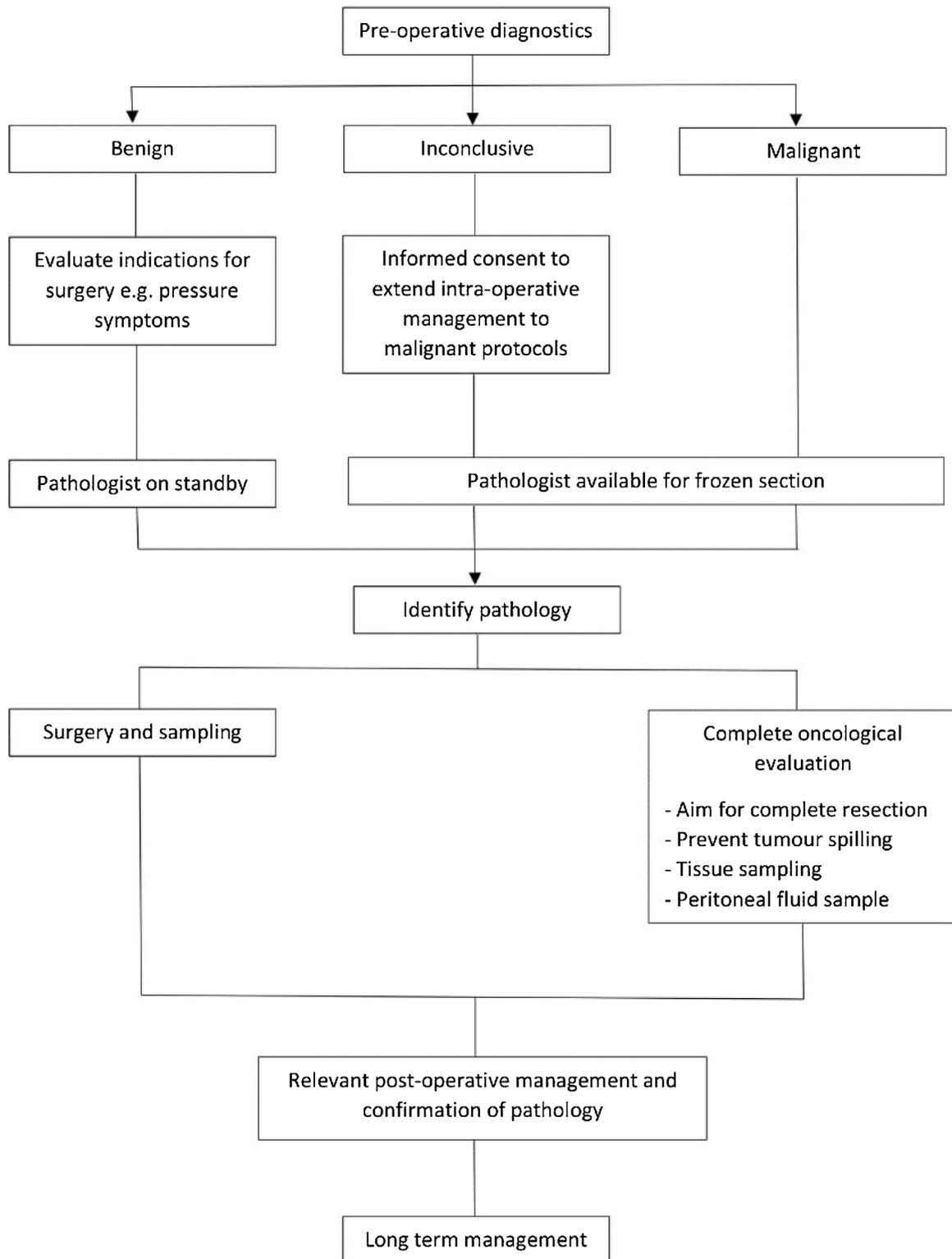
The size of the incision must validate the technical aspects of the surgery related to the tumour size, further exploration of organs and lymph nodes as well as sampling. To avoid the spilling of tumours, especially in larger masses, a laparotomy should be done in addition to a laparoscopy. Alternatively, it is possible to excise the mass and puncture it in a laparoscopic bag. This achieves a reduction the tumour size without spilling, but allows a removal by port site [44].

#### Medical interventions

Medical treatment is dictated by the final diagnosis. With an oncological diagnoses, a paediatric oncologist must be consulted, and speciality related physicians for benign diagnoses. Further supportive care, such as oestrogen replacement therapy in a case of bilateral ovariectomy, must be initiated.

#### Atypical clinical presentations

In cases where clinical and diagnostic testing do not correlate or define a conclusive diagnosis, pathologies normally reserved for adults should be considered. For these purposes tumour markers,



**Diagram 2.** Surgical approach to ovarian tumours.

such as carcinoembryonic antigen (CEA), and diagnoses more prevalent in older ages, such as carcinomas and myomas, can be investigated [34]. Malignant and borderline epithelial ovarian tumours in the pediatric and adolescent population are extremely rare but can be diagnosed by an elevated human epididymis protein 4 tumour marker [45,46].

#### Auxiliary services

Since patients in paediatrics, reproductive health and oncology are in vulnerable situations, psycho-social support through social services, psychologists, cultural and religious liaisons must always be offered.

## Ethics

When managing ovarian disease, several ethical factors are intrinsic to patient care and influence medical, emotional and psychological health originating from identity, fertility and planning for the future in terms of family planning and sexual health [47]. Informed consent forms part of both medical and surgical management to ensure that no harm or minimal negative short- or long-term irreversible effects with consideration of the risk-to-benefit ratio, are discussed [48]. Weighing psycho-emotional aspects such as aesthetics during large incisions for oncological management, in the presence of potential life-threatening diagnosis, are a priority [48]. This is especially true where loss of fertility or permanent internal and external scarification may occur. There are several considerations when a conclusive diagnosis will only be made during abdomino-pelvic surgery, which ranges from a basic diagnostic biopsy, removal of tissue and lifesaving interventions. Counselling should be provided in the presence of caretakers and psychologists as part of the multi-disciplinary team [48]. For these purposes team discussions may include religious representatives, adolescent health specialists, social services and even ethics committee representatives [49].

## Genetic counselling

Genetic counselling is important for three main reasons: Firstly, when a genetically linked disease is diagnosed that forms part of a syndrome with future sequelae, extensive counselling must be done and a long-term management plan for the screening, possible prevention and interventions for symptoms should be planned [50–52]. Secondly, where inherited diseases are diagnosed the risks of carrying them over to future children must be discussed [50–52]. Thirdly, in inherited diseases the risk of the development of the disease in other family members must be assessed and the family counselled, especially in autosomal dominant diseases [50–52].

## Multidisciplinary team approaches

Collaborative management partners share the responsibility to assess the scope of the health problem, planning the management and supporting the patient and family through the various hospital systems. This must be done in consideration not only of the culture, traditions and social importance of the patients, but also of various team members with their respective expertise, to enable the full decision-making capacity of all stakeholders involved. Everybody should benefit from the information and skills of the team to ensure the most beneficial and comprehensive medical care. This may include research opportunities that could benefit others beyond the treatment team.

## Conclusion

Ovarian tumours in children and adolescents are rare and predominantly benign, yet can present with local pressure symptoms or systemic symptoms of virilization. A high index of suspicion for malignant pathology, constituting a third of ovarian tumours, is important. During management a multidisciplinary team is essential for the physical and psycho-emotional wellbeing of this vulnerable population of patients.

## Declaration of Competing Interest

None.

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