Paediatric gynaecological ultrasound

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Introduction

Ultrasound (US) is the first-line imaging tool for assessment of the female pelvis, allowing increasingly high resolution images and excellent soft tissue contrast without need for sedation or radiation.

Transabdominal US remains the standard technique; the transperineal approach may be useful in neonates (cloacal malformations, mullerian anomalies, ectopic urethral insertions) and transvaginal US should be considered in older, sexually active adolescents for diagnosis of ectopic pregnancy.

Indications include follow-up of antenatal findings, eg neonatal ovarian cysts, ambiguous genitalia, mullerian-uterovaginal anomalies, pelvic masses and pain, prepubertal bleeding, delayed and precocious puberty and in the clinical assessment of eating disorders.

Normal US anatomy

In order to assess for disorders of development it is important to be able first to recognise normal US anatomy. There are age-related normative reference tables for uterine length, transverse dimensions and volumes and ovarian volumes. Different texts give slightly different values.

A useful rule-of-thumb for uterine development is the ratio of depth of the uterine fundus to that of the cervix on a sagittal US. The neonate is still under maternal hormonal influence, resulting in a bulky ‘spade-shaped’ uterus (cervix > fundus) measuring up to 5cm in length. The endometrial stripe may be prominent and the myometrium striated. The ovaries are often multifollicular, measuring on average 1cm.

The prepubertal uterus becomes tubular (fundus = cervix) and homogeneous with loss of endometrial stripe, measuring on average 2-3cm long. The ovaries (1-2cm) show few follicles.

Imminent puberty may be heralded by an increase in endometrial thickness (6-8mm), uterus (length >4cm), ovaries (2-4cm) and number of follicles (>6 at 4mm diameter).

The post-menarchal uterus attains the typical adult ‘pear’ shape (fundus > cervix; length 5-8cm) with a prominent endometrial stripe. The ovaries continue to enlarge (average 4cm; range 2.5-20cm) with a cyclical dominant follicle (10-29mm).

Pelvic masses

It is important to be aware of a number of potential pelvic US pitfalls.

Firstly, if the bladder is empty there is no acoustic window for adequate visualisation of anatomy. Furthermore, in this case, a large simple neonatal ovarian cyst may be inadvertently mistaken for the bladder.

Secondly, large masses may produce considerable anatomical distortion. A useful consideration, particularly in neonates, is whether the mass is pre-rectal (hydrometrocolpos, cloacal malformation) or post rectal (sacro-coccygeal teratoma (SCT), anterior myelomeningocele, rectal duplication, tail-gut remnant, dermoid, neuroblastoma (NB), bone tumour).

Apart from location, paediatric pelvic masses may be broadly categorised by age and character. In neonates and infants, consider ovarian cysts, congenital anomalies (renal, uterine, and neoplasia (SCT, NB, rhabdomyosarcoma (RMS))). In middle childhood, pelvic masses are less likely to be congenital anomalies but more likely to be neoplastic (RMS, lymphoma, ovarian tumours). Post-pubertal pelvic masses tend to be gynaecological (hydrometrocolpos, ovarian cysts and tumours) including conditions more commonly occurring in adulthood (pregnancy, pelvic inflammatory disease (PID)).

Regarding character of the mass, predominantly cystic masses include renal (in neonates obstruction, urachal cysts), gastrointestinal (enteric, mesenteric, omental cysts), gynaecological (ovarian cysts, uterovaginal obstruction), neuroenteric (anterior myelomeningocele) and neoplastic lesions (SCT, benign germ cell tumour (GCT), lymphangioma).

More complex solid masses (figure 1) are typically neoplastic (RMS, lymphoma, ovarian tumours, malignant GCT, NB, haemangioma, rarely ependymoma, chordoma), occasionally inflammatory (appendix abscess, PID) and possibly anatomical (pelvic kidney).

It is generally not useful to confer malignancy from the US characteristics of a solid mass, although increasing size and complexity are suggestive. Doppler imaging is sometimes helpful, with malignant tumours containing more low-flow dysplastic vessels (resistive index <0.4). This, however, is not specific; some malignant tumours demonstrate high-resistance flow, and conversely some inflammatory disorders may have low resistant flow.

Secondary US markers of malignancy may be more indicative, eg ascites (GCT), peritoneal deposits (epithelial cell tumour, sex cord stromal tumour), lymphadenopathy, hepatic metastases (rhabdomyosarcoma) (figure 2).

Bilateral homogenous ovarian enlargement should raise concern for haematologically spread metastases (lymphoma, leukaemia, NB, colon cancer).

Neonatal ovarian cysts

Antenatal US is detecting increasing numbers of neonatal ovarian cysts leading to postnatal follow-up US.

Cysts are defined by a diameter >10mm and are almost always due to follicular stimulation by maternal hormones, occasionally due to ovarian torsion. Commonly simple cysts, they may contain a small daughter cyst, but occasionally are complex (torsion, haemorrhage) and may auto-amputate (‘wandering tumour’) (figures 3a and b). Even then, there is little concern for malignancy, although benign neonatal ovarian tumours are recognised.

Management is therefore typically conservative US follow-up, with most cysts undergoing spontaneous resolution between 3-15 months of age without involution of the gonad.
Some centres advocate cyst aspiration for simple cysts >4 cm to prevent ovarian torsion and potential gonad loss.\(^\text{10}\) **Hydrometrocolpos**

This has a bimodal presentation, occurring in neonates under maternal hormonal stimulation and at puberty with onset of menses.

Clinical examination may be useful as perforate hymen, a common cause, may be associated with an interlabial mass.

The role of US is manifold. Firstly, to make the diagnosis of obstruction by demonstrating a fluid-filled uterus, cervix or vagina (figure 4) to locate its level (vagina, cervix), identify a single or duplex genital tract (mullerian anomaly), assess uterovaginal contents in clausal malformations (meconium, urine), document effects on bladder and kidneys and finally to exclude associated renal anomaly (ipsilateral renal agenesis or MCDK in uterus didelphys) or spinal dysraphism (cloacal malformation).

The importance of prompt diagnosis and correction of post-pubertal haematometocolpos lies in the untreated risks of haematosalphinx, endometriosis, infertility and ectopic pregnancy.

**Pre-pubertal bleeding**

US can be used to diagnose vaginal foreign bodies and rarely uterovaginal neoplasia. Precocious puberty may also present with vaginal bleeding in a young girl <8 years.

**Precocious puberty**

This is commonly defined as development of secondary sexual characteristics <8 years in girls. It is often idiopathic, however, exclusion of an underlying tumour (ovarian, adrenal) is necessary. Furthermore, diagnosis of a potentially treatable cause may not only prevent associated negative psychosocial effects but also reduce early bone maturations and improve adult height.

Precocious puberty has traditionally been classified as central or true (stimulation of hypothalamic-pituitary axis) and peripheral or pseudo (ectopic oestrogen production from eg ovaries, adrenal glands, liver). Clinically, hormone profiles allow differentiation.

US determines uterine and ovarian development for age and may identify an underlying cause, eg autonomously functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst. The more physiological, pulsatile hormonal stimulation that occurs with central precocious functioning ovarian cyst.

US of adrenal glands (congenital adrenal hyperplasia (CAH)) and liver (hepatoblastoma) should be part of the overall assessment.

**Primary amenorrhea**

This is defined as no menarche by 16 years. Again, there are many different causes involving the hypothalamic-pituitary (Kallmann syndrome), ovarian (polycystic ovarian syndrome, gonadal dysgenesis, Turner syndrome, virilising tumour), and uterovaginal (imperforate hymen, Müllerian anomaly) axis.

Other causes include adrenal (CAH, tumours), constitutional, iatrogenic (post radiotherapy) and rarely, disorders of sex differentiation (DSD).

The role of US is to assess ovarian and uterine maturations and exclude focal causative pathology, including within the adrenal glands.

**Mullerian anomaly**

There are a number of different classification systems\(^\text{11-13}\) reflecting the underlying difficulty in encompassing complex and variable abnormality. The most widely used is that of the American Society of Reproductive Medicine (ASRM).\(^\text{14}\)

Broadly, there is division of abnormality into disorders of agenesis, disorders of lateral fusion resulting in duplication defects (eg uterus didelphys) and vertical fusion resulting in canalisation defects (eg septate uterus, vaginal septum). Most present in later life with fertility issues.

The commonest to present at puberty are those associated with obstruction. Uterus didelphys, in particular, often presents at puberty with cyclical pain coexisting with normal menses due to unilateral uterine obstruction and is almost always associated with ipsilateral renal agenesis (Herlyn-Werner-Wunderlich Syndrome).\(^\text{15}\)

**Disorders of sex differentiation**

It is important to consider DSD in presentation of ambiguous genitalia.\(^\text{16}\) These can be classified as 46, XX DSD, 46, XY DSD and ovotesticular DSD. The commonest cause of ambiguous genitalia at birth is 46, XX DSD caused by CAH.

DSD may be associated with complex psychosocial issues, therefore multidisciplinary input including paediatric endocrinologists, urologists, radiologists, geneticists, psychologists and biochemists is essential.

US examination is directed to identifying the presence of uterus, ovaries (follicles) or testicles (mediastinum). Assessment of adrenal glands (CAH) and kidneys (Denys-Drash) is mandatory.

MRI, and sometimes genitography\(^\text{17-19}\) (US, fluoroscopic), may be necessary for full anatomical delineation. Imaging allows diagnosis of the underlying condition, location of occult gonads, pre-operative planning and assessment of suspected complications, eg malignant transformation to gonadoblastoma.

**Conclusion**

Modern US equipment allows exquisite imaging in an array of paediatric pelvic disorders. Recognition of normal US anatomy and potential US pitfalls, as well as knowledge of age-related disorders, is essential to assessment.
Figure 1
Transverse ultrasound of pelvic rhabdomyosarcoma. The partially filled bladder lies anteriorly. RMS may present as a large solid pelvic mass in infants and children.

Figure 2
Transverse US of peritoneal thickening and free fluid in the Pouch of Douglas. The patient had peritoneal deposits and ascites from ovarian cystadenocarcinoma.

Figure 3
Ultrasound of neonatal ovarian cysts. (A) simple, containing a daughter cyst and (B) complex, due to haemorrhage.

Figure 4
Sagittal ultrasound of post pubertal haematocolpos showing unilateral vaginal obstruction in an adolescent with uterine didelphys.