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PICTORIAL REVIEW

Beyond hernias: a multimodality review of abdominal wall pathology

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ABSTRACT

The diagnosis of abdominal wall pathology is often obvious on clinical physical examination; however, multimodality imaging often yields incidental, and occasionally important, findings aiding in assessing the overall clinical picture. While various hernias are common, there are numerous other causes of abdominal wall pathology. Knowledge of these entities is crucial to avoid misinterpretation and assure proper radiological judgment.

INTRODUCTION

The anterior abdominal wall is composed of muscle and fascial layers that serve many functions including containment, support and protection for the intraperitoneal contents and involvement in movement and breathing (Figure 1). While hernias are often encountered and well reviewed in the literature, less commonly seen abdominal wall pathology can be confusing when encountered or a pitfall when overlooked on imaging. This pictorial review briefly discusses the anatomy of the anterior abdominal wall and presents a multimodality pictorial review of a variety of abdominal wall abnormalities beyond hernias.

Congenital

Urachal anomalies arise from incomplete obliteration of the embryonic connection between the urinary bladder and the allantoic duct (Figure 2).¹ Failure of this process *in utero* results in a spectrum of anomalies including: patent urachus, urachal cyst, urachal sinus and urachal diverticulum.² A patent urachus is often easily diagnosed at birth with ectopic urine leakage through the abdominal wall at the umbilicus. Acquired urachal infection and urachal adenocarcinoma are two feared sequelae of urachal remnant disease that remain more difficult to diagnosis without the benefit of diagnostic imaging.

Vascular/trauma

Rectus sheath haematoma presents with acute abdominal pain and a palpable mass after trauma, muscular strain or in the setting of anticoagulation (Figure 3). The majority result from the rupture of epigastric vessels or tearing of the rectus abdominis muscle fibres.³ The natural course is

typically self-limited, as the bleeding eventually tamponades itself.

Vascular shunts are often clinically evident from prominence of vessels in the abdominal wall (Figure 4). Abdominal wall venous collateral vessels may occur in the setting of systemic venous occlusion or portal hypertension. Under extreme pressure, the recanalized para-umbilical vein within the round ligament can reopen to allow the passage of blood and is highly specific for portal hypertension. These vessels present an additional risk during paracentesis or other similar procedures that penetrate the abdominal wall.

Inflammatory

Cellulitis/abscess of the abdominal wall classically presents with focal tenderness, overlying erythema, fever and/or leukocytosis (Figure 5). This acute infection of the dermis and subcutaneous tissues occurs following disruption of the skin and invasion from either indigenous flora or exogenous bacteria. Abdominal wall abscesses can occur in patients who are post-operative or post-traumatic and can occasionally arise spontaneously as extension of an intra-abdominal process such as in Crohn disease.

Necrotizing fasciitis is a rare and rapidly aggressive soft-tissue infection most commonly seen in diabetics (Figure 6). It is usually caused by underlying infection of the lower genitourinary tract or soft tissues of the perianal region. While difficult to clinically differentiate in the early stages of disease, diagnosis and treatment is paramount with mortality rates as high as 70–80%.⁴

Figure 1. An axial CT image is demonstrating the anatomy of the abdominal wall.

Scar endometriosis typically results in a palpable abdominal wall mass with cyclical pain during menses in females with a history of caesarean delivery (Figure 7). Endometrial stem cells can be

ectopically implanted along the course of the surgical incision within the abdominal wall skin, subcutaneous tissue or rectus sheath.⁵

Figure 2. Reformatted CT images and greyscale ultrasound are demonstrating two types of urachal anomalies with abdominal wall involvement: (a, b) a 39-year-old male with acquired infection of urachal cyst (arrow)—the sagittal CT image (a) is demonstrating a fluid-filled structure with wall enhancement just deep to the umbilicus. Greyscale ultrasound (b) is depicting a mixed echogenicity mass with a thick outer wall and shaggy inner margin. (c, d) A 52-year-old female with urachal carcinoma: the axial and sagittal CT images (c, d) are demonstrating a mass invading the anterosuperior bladder wall and abdominal wall with portions of eccentric calcification, common in urachal neoplasms.

Figure 3. CT images and a greyscale ultrasound demonstrating rectus sheath haematomas: (a, b) a 62-year-old female on Coumadin® (Bristol-Myers Squibb, Princeton, NJ) with acute pain and a palpable abdominal wall mass—axial CT (a) is demonstrating active extravasation of the contrast (arrow) into the confined rectus sheath haematoma. Greyscale ultrasound (b) is depicting heterogeneity within the rectus sheath with variable echogenicity corresponding to variable aged blood products. (c, d) A 52-year-old female with lower abdominal pain after a fall: axial CT (c) is demonstrating a haematoma (arrows) bounded by the rectus sheath without active extravasation.

Neoplastic

Lipomas are benign mesenchymal tumours that resemble normal fat. They are most often found within soft tissues and skeletal muscle, but can arise in any region of the body that contains fat (Figure 8).⁶

Desmoid tumours are benign non-inflammatory fibroblastic tumours often associated with Gardner syndrome, previous trauma or surgical incision and have a strong prevalence among reproductive-age females (Figure 9).⁷ They tend to locally invade and recur without metastasis.

Figure 4. Reformatted CT images of vascular shunts within the abdominal wall: (a–d) a 74-year-old male with portal hypertension—the axial (a, b) and sagittal (c, d) CT images are demonstrating recanalization of the umbilical vein within the round ligament (arrows). (e) An 82-year-old female with inferior vena cava occlusion: the axial CT image (e) is showing numerous venous collaterals coursing through the abdominal wall to compensate for central venous occlusion (arrow).

Figure 5. CT and greyscale ultrasound images of cellulitis and abscesses involving the abdominal wall: (a, b) a 65-year-old male with new onset right abdominal pain and tenderness—the axial CT image (a) is showing the skin and underlying fascial thickening (arrow) without central fluid collection. The greyscale ultrasound image (b) is demonstrating diffuse thickening, increased echogenicity and a cobblestone appearance of the subcutaneous tissue. (c) A 73-year-old female with new onset pain and tenderness at an ostomy site: the axial CT image (c) is showing superficial extension to the ostomy site from abdominal wall rim-enhancing fluid collection (arrow). (d, e) A 40-year-old male with fever and right abdominal pain and swelling: the axial CT image (d) is depicting well-defined rim-enhancing fluid collection (arrow) involving multiple abdominal wall fascial planes. The greyscale ultrasound image (e) is showing a hypoechoic complex fluid collection with areas of hyperechoic debris.

Condyloma acuminatum is pink- or flesh-coloured macules or verrucous papillomas and is a clinically evident manifestation of the sexually transmitted human papilloma virus (Figure 10).

Patients who are immunosuppressed are at the greatest risk of transmission and development of malignant transformation into invasive squamous cell carcinoma.

Figure 6. Radiographic and CT images of necrotizing fasciitis: (a, b) a 79-year-old diabetic in sepsis—the supine portable radiograph of the abdomen (a) is depicting extraluminal gas (arrow) projecting over the left iliac wing. The axial CT image (b) is confirming the plain film finding that the gas collection is within the subcutaneous tissues with associated thickening of the fascial planes (arrow). (c, d) A 60-year-old male diabetic with known anorectal infection: the sagittal and axial CT images in lung windows (c, d) are demonstrating the extension of subcutaneous air from the perineum to the lower abdominal wall.

Figure 7. Ultrasound and MR images of the pelvis with scar endometriosis: (a–f) a 33-year-old female with an abdominal wall mass causing cyclical pain—the greyscale and colour Doppler ultrasound images (a, b) are demonstrating a vascular hypoechogenic infiltrating mass at the site of previous caesarean section scar. Axial and sagittal T_1 (c, d) and T_2 (e, f) images are demonstrating a mass lesion (arrows) superficial to the rectus sheath that is T_1 isointense to the skeletal muscle and T_2 hyperintense, which may correlate to aged blood products.

Neurofibromas are benign neoplasms composed of schwann cells and a network of collagen fibres presenting most commonly in neurofibromatosis Type 1 (NF1) or 2 (Figure 11). Localized

neurofibromas are usually solitary and sporadic; however, plexiform neurofibromas are associated with (NF1). Multiple neurofibromas are virtually diagnostic of NF1. Lesions not

Figure 8. CT, ultrasound and MR images of a lipoma: (a–e) a 23-year-old male with a palpable lesion on the right flank—the axial CT image (a) is showing a well-circumscribed ovoid, fat-attenuating intramuscular mass (arrow) with a thin capsule and thin septations. The greyscale ultrasound image (b) is depicting a well-defined isoechoic/hyperechoic mass with a thin echogenic capsule. Axial T_1 (c), T_2 (d) and T1 fat saturation + gadolinium (e) images are demonstrating a mass that is following the fat signal on all sequences without enhancement.

Figure 9. Ultrasound, CT and MR images of a desmoid tumour: (a–e) a 40-year-old male with an asymptomatic palpable mass on the left lower abdominal wall at the site of a previous incision—the greyscale ultrasound image (a) is showing a hypoechoic mass with well-defined borders. The axial CT image (b) is showing a solid minimally enhancing mass (arrow) that is isodense to the muscle. Axial T1 fat saturation (c), T2 fat saturation (d) and T₁ + gadolinium (e) images are demonstrating a heterogeneously enhancing mass that is T₁ hypointense to the muscle, T₂ hyperintense to the muscle with hypointense septations representing areas of fibrosis.

associated with NF1 are usually surgically excised, whereas lesions associated with NF1 are often non-surgical owing to multiplicity of lesions.

Metastatic deposits are usually clinically evident, but may be overlooked, particularly in the patient with obesity (Figure 12). Typical primary lesions that cause subcutaneous

Figure 10. CT and MR images of condyloma acuminatum: (a–c) a 39-year-old immunodeficient male with a history of human papilloma virus infection with flesh-coloured papillomas on the lower abdominal skin—the axial CT image (a) is demonstrating a verrucous growth (arrows) along the lower abdomen skin surface. Axial T₂ (b) and T₁ + gadolinium (c) images of the pelvic skin are showing an enhancing mass that is T₂ hyperintense to the muscle, also consistent with verrucous papillomatosis.

Figure 11. CT and MR images of a neurofibroma: (a–f) a 20-year-old female with NF1 and a palpable left flank mass—the axial non-contrast CT (a), contrast-enhanced (b) and coronal contrast-enhanced (c) images are showing a well-defined solid soft-tissue mass (arrow) with minimal enhancement. Axial T_1 (d), T_2 (e) and T_1 + gadolinium (f) images are demonstrating a heterogeneously enhancing mass that is T_1 hypointense and T_2 hyperintense to the central area of low signal.

metastases include melanoma, lung, renal and ovarian cancer.⁸ Direct spread of a variety of intra-abdominal malignancies to the abdominal wall is also common.

Rarely, percutaneous biopsy can seed subcutaneous metastasis most commonly in breast cancer and hepatocellular carcinoma.

Figure 12. CT and MR images of metastatic deposits within the abdominal wall: (a) a 68-year-old female with ovarian cancer—the axial CT image (a) is demonstrating a large pelvic mass with a smaller, discrete ovoid mass (arrow) of the same density that is superficial to the rectus sheath. (b) An 82-year-old male with history of melanoma: the axial CT image (b) is demonstrating multiple circumscribed soft-tissue masses (arrows) in the anterior and posterior abdominal walls. (c) A 76-year-old female with history of hepatocellular carcinoma: the axial CT image (c) is demonstrating multifocal hepatocellular carcinoma with extrahepatic metastasis (arrow) involving the adjacent abdominal wall. (d, e) A 54-year-old male with hepatocellular carcinoma status post-percutaneous biopsy: the axial T_2 (d) and T_1 + gadolinium (e) images are demonstrating a mass (arrows) following tumour signal that is just deep to the linea alba along a needle tract from recent percutaneous biopsy, indicating seeding of tumour.

Figure 13. Ultrasound and CT images of seroma formation: (a-c) a 64-year-old female status post-laparotomy with a non-tender fluctuant abdominal wall—the greyscale images (a, b) are demonstrating an avascular anechoic collection with posterior acoustic enhancement. The axial CT image (c) is demonstrating low attenuation fluid collection (arrow) without internal enhancement at the surgical site.

Iatrogenic

Seroma formation usually occurs as a complication of surgery, but can also be seen following trauma (Figure 13). Serous fluid is a proteinaceous fluid that accumulates with local haemorrhage and is thought to be due to disruption of lymphatic and vascular

channels. Most resolve within 30 days; however, drainage is indicated if symptomatic or unresolved after 6 weeks.

Foreign body granulomas represent a benign granulomatous proliferation in response to a retained foreign body (Figure 14).

Figure 14. Ultrasound and CT images of foreign body granulomas in the abdominal wall: (a-c) a 65-year-old male status post inguinal hernia repair with mesh and suture material is presenting with a palpable tender mass at the incision site—greyscale (a) and colour Doppler (b) images are demonstrating hypoechoic collection with mild vascularity and a small hyperechoic structure within the collection (a suture) (arrows). The axial CT (c) image is depicting a metallic foreign body within the peripherally enhancing mass (arrow).

Figure 15. CT images of sequela of superficial injections of the abdominal wall: (a) a 45-year-old male undergoing repeated subcutaneous injections—the axial CT (a) image is demonstrating multiple small locules of gas (arrow) within the subcutaneous tissues at the site of recent injection. (b) An 85-year-old male status post-subcutaneous heparin injection: the axial CT (b) image is showing well-defined small nodules (arrow) in the left abdominal wall correlated to recent injection. (c) A 50-year-old male with history of subcutaneous injections to the abdominal wall and buttocks: axial CT (c) is demonstrating a calcified injection granuloma (arrow) superficial to the left gluteus maximus.

The most common culprits are surgical sutures, surgical sponges, teflon or activated charcoal.

Superficial injections are an incidental clinically insignificant finding (Figure 15). Any recent subcutaneous injection may result in subcutaneous air. Subcutaneous (intralipomatous) rather than intramuscular injection of drugs can cause localized fat necrosis, scar formation and dystrophic calcification. Heparin

products can incite delayed hypersensitivity reactions at the injection site, resulting in skin necrosis, skin nodule and inflammatory plaques.

Lipohypertrophy is focal subcutaneous fat proliferation most commonly occurring in Type I diabetics, who inject insulin into the subcutaneous tissue (Figure 16). Local pain sensation decreases as lipohypertrophy develops, resulting in preferential

Figure 16. CT images and three-dimensional (3D) CT reconstruction of lipohypertrophy in the abdominal wall: (a) a 79-year-old insulin-dependent female who, over the course of many months, has repeatedly injected insulin in two places on the lower abdominal tissues—the axial CT (a) image is demonstrating focal rounded areas of fat accumulation (arrows) under the skin where insulin injections were administered. (b, c) A 67-year-old insulin-dependent male who also repeatedly injects insulin in two places in the lower abdominal soft tissues: the axial CT (b) and 3D CT reconstruction (c) images are demonstrating soft-tissue masses (arrows) and fat proliferation in a symmetric distribution related to the history of repeated insulin injections.

Figure 17. CT images of transverse rectus abdominis myocutaneous (TRAM) flap procedure for breast reconstruction following mastectomy: (a–c) a 45-year-old female status post-mastectomy with a TRAM flap procedure—CT sagittal right (a), CT sagittal left (b) and axial CT (c) images are demonstrating the absence of the left rectus abdominis muscle (arrow) used for right breast reconstruction (arrow).

injection of insulin at that site. It is important to recognize, as insulin absorption is impaired in these areas.

The transplantation of a transverse rectus abdominis myocutaneous flap is a commonly used surgical procedure for breast reconstruction following mastectomy (Figure 17). It consists of an autologous myocutaneous flap comprised of abdominal skin, subcutaneous fat, the rectus abdominis muscle and adjoining vasculature. The transverse rectus abdominis myocutaneous flap is based

on the superior epigastric vessels and uses the contralateral rectus abdominis muscle in its entirety for unilateral reconstruction. Complications include ventral abdominal bulging or hernia at the donor site related to diminished abdominal wall integrity.

Several medical devices can be implanted within the abdominal wall (Figure 18). Unless the device was recently placed, the presence of gas or fluid around the implant should raise suspicion of infection.⁹

Figure 18. CT images of various medical devices commonly found in the abdominal wall: (a, b) a 79-year-old male with a penile prosthesis—sagittal CT (a) and axial CT (b) images are demonstrating a penile prosthesis (arrows) with an intrapelvic reservoir. (c) A 67-year-old male with a right axillary artery to right femoral artery bypass: coronal CT (c) and axial CT (d) images are demonstrating this bypass (arrows) as it enters the abdominal wall at the external oblique and then courses between external and internal oblique muscles into the lower abdomen, at which point it enters the superficial soft tissues of the pelvis to anastomose with the right iliac artery. (e) A 78-year-old male with a peritoneal dialysis catheter entering through the abdominal wall: the axial CT (e) image is demonstrating a peritoneal dialysis catheter (arrow) coursing through the abdominal wall with the internal tip ending in the left lower quadrant.

(a)

(b)

(c)

(d)

(e)

Liposuction is a cosmetic procedure commonly performed on the trunk to reduce “target fat” leaving a desired body contour. Currently, there are many surgical techniques for liposuction including powered liposuction, laser-assisted lipolysis, chemical lipolysis and ultrasound-assisted liposuction.¹⁰ While powered liposuction usually achieves the goal of a reduction in adipose

tissue, this method also leaves behind characteristic concentric fibrous scars encircling the abdominal wall (Figure 19).

CONCLUSION

The abdominal wall, comprised of skin, subcutaneous tissues, muscular and fascial layers, serves important containment and supportive

Figure 19. CT images showing the concentric fibrous bands seen after power liposuction: (a, b) a 38-year-old female status post-liposuction—the axial CT (a) and sagittal CT (b) images are demonstrating concentric fibrous bands (arrows) within the abdominal wall adipose tissue.

functions. Attention to the abdominal wall should be included in every search pattern and familiarity with a variety of processes

affecting the abdominal wall will enable the astute radiologist to efficiently diagnose pathology and assist in patient management.

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