REVIEW

All that glitters are not gold: holds true in female adnexal lesions

Mohamed Rafi Kathar Hussain, N. Kulasekeran, A. M. Anand and Rajasree Dhinadhyalan[*]

Abstract

Background: Adnexal mass lesions are commonly encountered pathologies that creates diagnostic challenges for radiologist. Diffusion weighted imaging is a vital tool in the radiologist armamentarium for improving the diagnostic accuracy of adnexal lesions other than routine spine echo sequences.

Main body: Functional information about the lesion regarding the mobility of the water molecules in its tissue is assessed by diffusion weighted imaging. In addition to the solid malignant neoplasm, normal blood, fat, necrosis and pus also shows restricted diffusion.

Conclusion: All the lesion that shows restriction in the DWI are not malignant, but converse is mostly true. Knowledge regarding the non-malignant lesion in the ovary that shows restricted diffusion will give a clue in diagnosis, management and treatment of the adnexal lesions.

Keywords: DWI, Adnexa, Female, Ovary, Restricted diffusion

Background

Adnexal mass lesions are commonly encountered pathologies that creates diagnostic challenges for radiologist. The morphological analysis of lesion character by USG will help in most of the cases [1]. But MRI plays a significant role in differentiation by assessment of soft tissue characteristics. In addition to routine spin echo sequences, it is an indisputable fact that DWI provides a good characteristic of the lesion [2]. In general, all over the body; Diffusion restricted lesions are malignant. The main purpose of this review article is there are many exceptions to the above general statement. All DWI restricted lesion are not malignant, and all malignant lesion will not show diffusion restriction. DWI imaging is a vital tool in the radiologist's armamentarium, in improving the diagnostic accuracy of adnexal lesions and avoiding the pitfalls during interpretation [3].

Basics of DWI

The tissues in the body has water molecules that show constant and random motion, known as brownian movement, which is slowed down by interaction with the cell membranes and intracellular organelles. DWI gives the information about the brownian motion of the moving water molecules at cellular levels [4]. Increased cellularity in the tissues makes the surface area of cell membrane to increase, thus decreasing the brownian motion. ADC quantifies loss of signal in corresponding high signal areas of DWI,which is called as restricted diffusion. The b value predicts variable diffusion gradient strengths which is used to acquire the DWI image and it is expressed as s/mm^2 (time/area) [5].

Pitfalls in DWI

In addition to the malignant neoplasm which shows restricted diffusion; Hemorrhage, fat, necrotic areas and abscess may also shows restricted diffusion [6]. This leads to overlap in the radiological diagnosis which creates a diagnostic challenge with neoplastic lesion [7]. T2 WI also helps in assessment of DWI signal intensity. The tissues having increased T2 relaxation time will show high

*Correspondence: dhinadhayalan.rajasree@gmail.com
Department of Radio Diagnosis, Sri Manukula Vinayagar Medical College, Kalitheerthalkuppam, Puducherry, India

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signal intensity in DWI and ADC is called T2-shine-through effect. Some lesions cause hypointense signal on DWI, the ADC map, and T2W images. This is called as T2-blackout effect. This T2 blackout effect is seen in fibrous lesions and chronic hemorrhage. We will describe the lesions which are exception to the general rules of DWI as given in the Table 1.

Normal ovaries are oval in shape with average volume ~ 10 cm^3 normally [7]. On T2W images the zonal anatomy of ovary is best seen. The normal medulla with respect to cortex shows increased signal intensity. Usually the medulla has an increased amount of stroma which is loosely packed and blood vessels. Cortex which has thin walled follicles shows high signal in T2WI and low signal intensity on T1W images [7]. Contradictory to it, corpus luteum has thick wall, shows intermediate to low signal intensity on T2W images, which corresponds to a layer of theca cells [8]. Sometimes, the normal ovary may show increased signal intensity on DWI sequences, especially during the luteal phase due to T2-shine-through effect. The thin walled ovarian follicles, on all DWI sequences shows high signal intensity (even at high b values), with corresponding high ADC values [9].

Mature cystic teratoma

For women under 45 years of age, mature cystic teratoma is the most common ovarian tumors [10]. They are combination of endoderm, mesoderm and ectoderm or any of the two-germ cell layer. Most of the teratomas are unilateral except for 10% which are bilateral. They have a slow growth rate at an average growth of about 1.8 mm each year. Most of the mature cystic teratomas have sebum within, which at body temperature gets liquified. The lining of teratoma is keratinized squamous epithelium [11]. They have hair follicles, glands, muscle component, and other solid tissues. Rokitansky nodule, an eccentric nodular projection is seen projecting into the cystic lesion in most of the lesion. Since they have adipose content, they show both T1 and T2 high signal intensity which becomes hypointense on fat saturation. This specific characteristic is sufficient to diagnose it as ovarian teratoma [12].

It is suggested that keratin component displays an abnormal increased signal intensity on DWI in most mature cystic teratomas. Restriction of Brownian motionof the molecules inside the keratinous material leads to DWI high signal intensity and low ADCs. DWI can facilitate the diagnosis of mature benign cystic teratomas, which has small amount of fat that is not identified by other conventional sequences (Fig. 1a–d). Loss of the normal diffusion restriction in certain areas which are previously restricted shows raise the suspicion of malignancy in teratoma.

Endometriomas

Endometriomas are the ectopic endometrial tissue outside the endometrium. There tissues responds to hormonal stimulation leading to repeated hemorrhage during menstruation. Patient usually presents with recurrent cyclical abdominal pain. T2 shading is the classic feature of endometriomas which appear as linear dependent hypointense signal within the lesion. The degraded blood products, protein and iron deposition appear hyperintense on T1with corresponding hypointense signal on T2WI.

Due to the presence of blood and some hemosiderin, endometriosis shows lower signal on ADCs, high signal intensity on DWI with T1 shortening [13]. Benign endometrioma will shows restricted diffusion, but loss of the diffusion restriction on previously diagnosed benign lesion should raise the suspicion of malignant transformation. The most frequent malignant tumors associated are clear cell and endometrioid carcinomas. Along with change in diffusion pattern with presence of intermediate signal intensity on T2W images, thick septa, post- contrast enhancement in solid nodules and peritoneal metastases are features of malignant transformation [14]. Mapping DWI and ADC also plays an important role in differentiating between endometrioma and hemorrhagic cyst. ADCs shows low signal in endometriomas than in hemorrhagic cysts. This can help in differentiating between the two conditions. (Fig. 2a–f).

Table 1 MRI features of various adnexal lesions

S. no	Lesion	T1	T2	DWI	ADC
1	Mature cystic Teratoma	Hyperintense	Heterogeneous, predominantly hyperintense	Hyperintense	Hypointense
2	Endometrioma	Hyperintense	Hypointense to intermediate Signal	Hyperintense	Hypointense
3	Ovarian Torsion	Hyperintense	Hyperintense	Hyperintense	Hypointense
4	Tubo-ovarian abscess	Heterogenous	Heterogenous, predominantly hyperintense	Hyperintense	Hypointense
5	Fibroma	Hypointense	Hypointense to Intermediate signal	Hypointense	Hypointense

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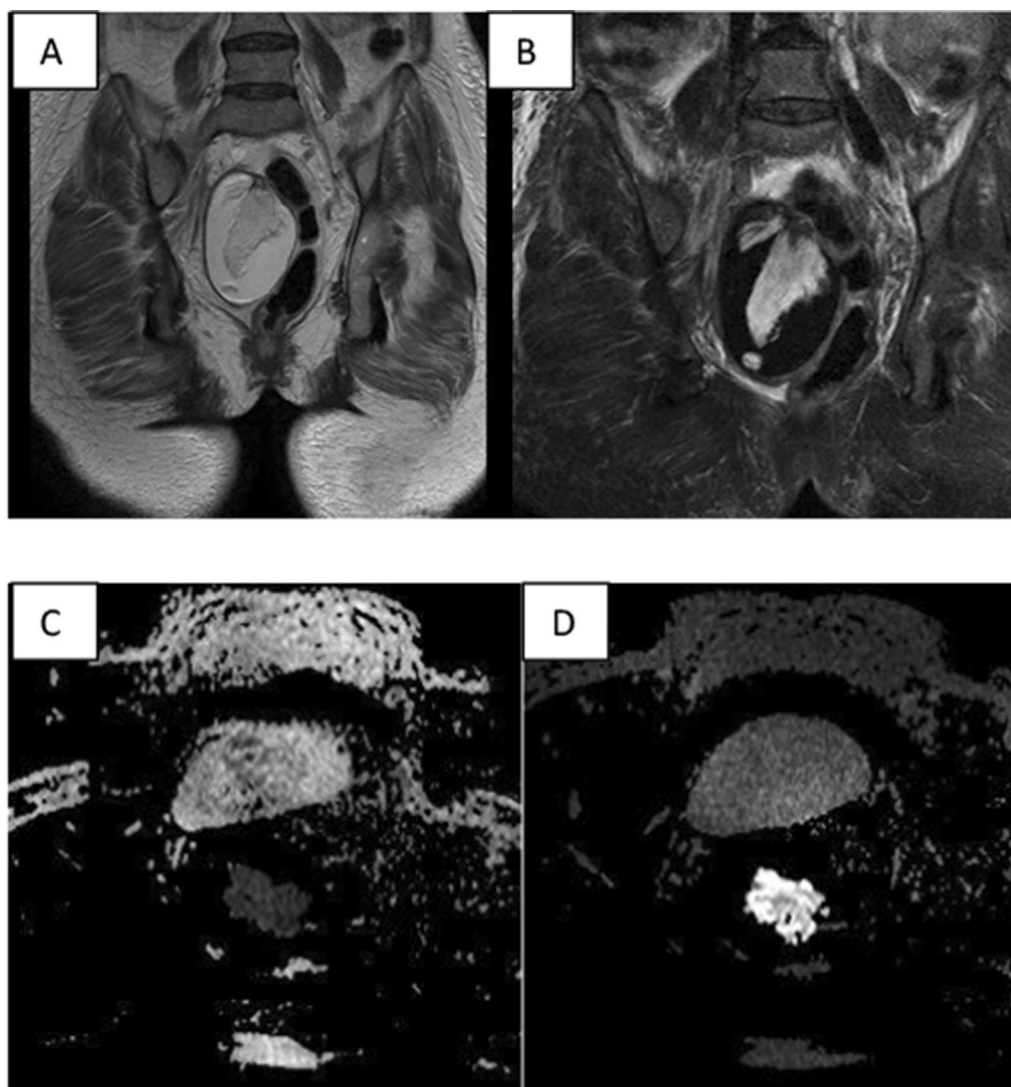
Fig. 1 Shows 38-year-old female with lower abdominal pain. **a** T2W MRI coronal image shows well defined hyperintense right ovarian lesion. **b** Fat saturation sequence shows suppression of fat within the lesion. **c**, **d** shows DWI image axial section with areas of restricted diffusion and corresponding signal loss in ADC. MRI features suggestive of mature cystic teratoma. CT of the same patient shows presence of Fat, calcification and soft tissue elements in the right ovary

Ovarian torsion

Complete or partial rotation of the ovarian vascular pedicle which causes obstruction to vascular flow is defined as ovarian torsion. Adnexal torsion is unilateral more common on the right side with a 3:2 predilection. Benign tumors such as mature cystic teratoma, ovarian cyst are the common predisposing factors associated with torsion [15]. It occurs due to the twists of suspensory ligament. Suspensory ligament is the one that attaches the ovary to pelvic sidewalls. Initially torsion compromises the venous blood flow and lymphatic outflow. This will lead to ovarian edema and bulky ovary on imaging. Later, as torsion progresses there is compromise of arterial circulation leads to thrombosis, progressing to ischemia and ovarian infarction [16].

Immediate surgical intervention is essential [17]. If it is left untreated ovarian infarction will progress to infection, leading to peritonitis and can further lead to intestinal obstruction. If there is partial torsion it will lead to intermittent pain and relief on spontaneous untwisting within hours, days, or weeks [18]. Imaging features of partial torsion will vary depend upon which stage of torsion imaging was done. Early surgical detorsion can prevent salphingectomy and other complications. The

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Fig. 2 A 40 year old female came with recurrent cyclical abdomen pain varying with menstrual cycle. **a**, **b** Sagittal T1 and T2W MRI shows well defined cystic lesion seen in the posterior fornix and torus uterinus. The lesion appears T1-Hypointensity and T2- Hyperintensity, probably originating from the left ovary. Left ovary not seen seperately. **c**, **d** ADC and DWI axial image demonstrating few areas of T2 shadowing and the lesion shows Restricted diffusion, **e** T2 fat suppression axial section which appears hyperintense. No evidence of fat suppression. **f** on FFE sequence, complete hemosiderin rim seen.MR Imaging features suggestive of endometrioma arising from the left ovary, confirmed by surgery

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salvage rate is very low in adults (below 10%) when compared to children 27% [19].

In ovary with torsion, the mean ADC valueis lower than that of ovary without torsion. And it is significantly lower in patients with hemorrhagic infarction [20]. Torsion leads to cytotoxic edema and causes diffusion restriction on DWI [21]. Meanwhile hemorrhage will have magnetic susceptibility effect on DWI which results in low ADC values [22, 23].

Tubo-ovarian abscess

Tubo-ovarian abscess may appear as a frank abscess or tubo-ovarian inflammatory mass, which results from breakdown of fallopian tubes and ovaries. TOA is most common in patients with Pelvic inflammatory disease. Use of an intrauterine device (IUD), like Cu-T is associated with an increased incidence of TOA in young patients [24].

If the content of tubo-ovarian abscess becomes more viscious, it shows restricted diffusion in DWI with corresponding low signal on ADC map [25] (Fig. 3a–d). But in chronic abscesses or abscesses smaller than 1 cm, if started on antibiotic therapy will not show restricted diffusion on DWI [26].

Fibroma or thecoma

Around 4% of all ovarian neoplasm's accounts for fibromas [27]. Most commonly seen in 4th decade. They are classified into two types either cellular fibromas or fibrosarcoma's. Malignant potential is low in cellula fibromas, whereas fibrosarcoma's have a high malignant potentials [28]. On T1W and T2W MRI, fibromas usually show low intensity signal and delayed post- contrast enhancement. T2 shows a predominantly low signal intensity lesion which is due to increased collagen and the reduced extracellular fluid [29]. On T2W images, few areas of shows intermediate to high signal intensity due to edema and cystic degeneration [30].

Thecomas presents around 0.5–1.0% of all ovarian tumors and are more common in post- menopausal
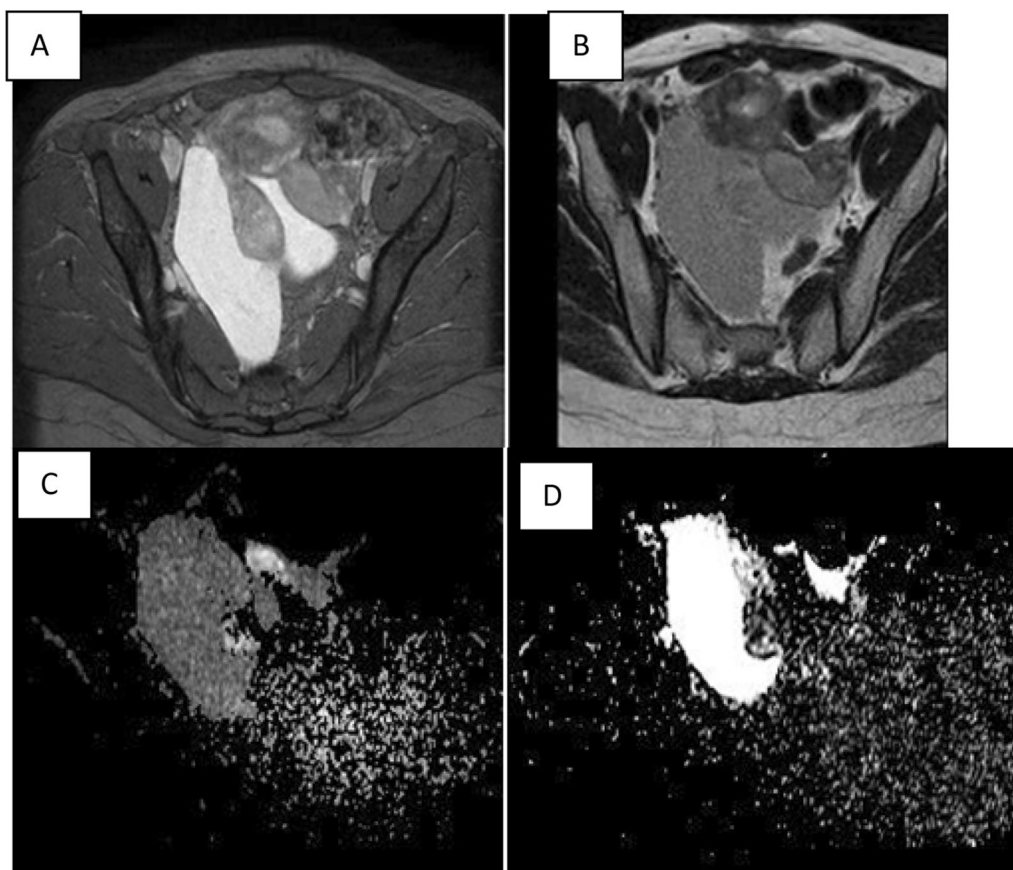
Fig. 3 A 30 year old female with fever, vaginal discharge and lower abdominal tenderness. **a**, **b** T2WI and T1WI axial section shows well defined solid and cystic lesion in the left adnexa, which appears T2 hyperintense and T1 hypointense. Adjacent mesosalpinx appears mildly thickened and inflammed. Surrounding pelvic fat planes shows mild enhancement. **c**, **d** shows restricted diffusion on DWI images with corresponding signal loss in ADC. MRI features suggestive of Tubo-ovarian abscess. Patient also had a peritoneal inclusion cyst on right side

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women. They are considered as benign neoplasms [31]. They will estrogenic activity due to hormonal production. On MRI, on comparison with fibrous tumors, pure thecomas exhibits a higher signal intensity on T2W images and more avid post-contrast enhancement.

According to the European Society of Urogenital Radiology, recent guidelines for adnexal masses, a solid lesion that depicts a low signal intensity on T2W images and restricted diffusion in DWI with high b values is highly predictive of benignity [32]. Low value of ADCs in fibrous tumors is due to dense fibrous stromal proliferation. And it is called as T2 blackout effect (Fig. 4a–d). Few fibromas and thecomas rarely show restricted diffusion [33, 34].

Conclusions

DWI image plays an important role in the diagnosing the ovarian adnexal lesion. All the lesion that shows restriction in the DWI are not malignant, but converse is mostly true. Knowledge regarding the nonmalignant lesion in the ovary that shows restricted diffusion will give a clue in diagnosis, management and treatment of the ovarian lesion.

Learning points

1. Lesion that shows restriction in DWI are not always malignant.
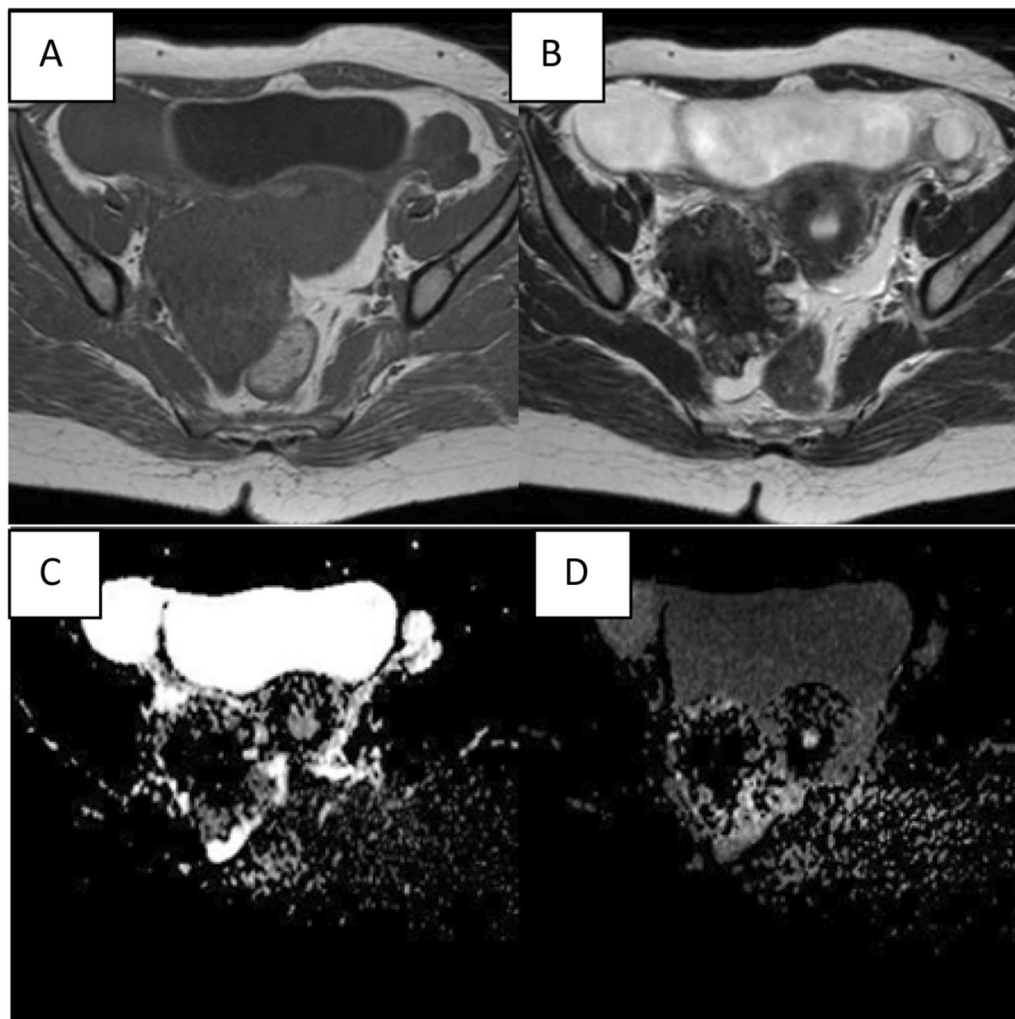
Fig. 4 A 40-year-old female came with irregular menstruation and lower abdominal pain. **a**, **b** MRI pelvis shows well defined T1 intermediate signal and T2 Hypointense mass with nodular surface in right adnexa. Low signal on T2WI depictsthe fibrous contents within the lesion, **c**, **d** lesion appear Hypointense on both DWI and ADC images. On post contrast, lesion shows delayed mild heterogeneous enhancement. Lesion is confirmed as Fibrothecoma by histopathology

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2. Normal hemorrhage, lipid component, necrotic tissues and pus will also show restricted diffusion.
3. Benign fibrous ovarian lesion will not show restricted diffusion, there will be T2 blackening effect.

Declarations

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