Fallopian tube disease on magnetic resonance imaging

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Abstract

Knowledge about fallopian tube disease is essential in the assessment of the pelvis in female patients. Primary and secondary changes in the tubes vary widely, regardless of whether associated changes in the ovaries are present. Ultrasonography is the initial technique in the study of adnexal disease because it is very sensitive and widely available; however, MRI is also very useful in this context because its high tissue resolution and anatomic detail make it more specific. The morphologic findings and the characteristics of the contents of the tubes on MRI enable a more accurate diagnosis or limit the differential diagnosis, helping to ensure that the most appropriate treatment is provided in each case.

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Palabras clave

Resonancia magnética; Dilatación tubárica; Masa anexial; Neoplasia tubárica; Endometriosis tubárica; Enfermedad inflamatoria pélvica

Estudio de las enfermedades de las trompas de Falopio mediante resonancia magnética

Resumen

Conocer las enfermedades de las trompas de Falopio es esencial para valorar la pelvis ginecológica. Las alteraciones primarias y secundarias de las trompas, cursen o no con alteraciones ovarias asociadas, son muy variadas. Pese a que la ecografía, por su gran sensibilidad y disponibilidad, es la técnica inicial para estudiar las alteraciones anexiales, la RM es muy útil en el diagnóstico de las enfermedades tubáricas porque su elevada resolución tisular y el detalle anatómico que proporciona le confieren una mayor especificidad. Los hallazgos morfológicos y las características del contenido tubárico con la RM posibilitan un diagnóstico más preciso o limitan el diagnóstico diferencial y permiten orientar el tratamiento más adecuado en cada caso.

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Introduction

There are many different dysfunctions in fallopian tubes—severe, chronic, primary and secondary and getting to know these is important to assess gynecologic pelvis. Ultrasound is the initial elective technique to study gynecologic diseases, even though in many occasions computed tomography (CT) can be the first test to use because of its great availability for an initial non-gynecological clinical suspicion or in the emergency setting. However specificity of these two diagnostic modalities is low. Complex tubaric dysfunctions with atypical clinical presentation or when associated with an ovaric dysfunction creating a complex adnexal mass, magnetic resonance (MR) is the most indicated test because of its greater sensibility and specificity.

MR allows us to better characterize adnexal dysfunctions since in many cases it distinguishes between single tube disease (if tubes are involved only) and complex tube disease (if other organs are involved—usually ovaries). Similarly it characterizes the tube content better than ultrasound and CT thanks to its signal intensity in different sequences. Other than obtaining more precise diagnoses it does so in earlier stages than ultrasound avoiding ecographical follow-up delays. In sum in many cases MR diagnosis allows us to start conservative therapies against benign disease or more aggressive when suspicious of neoplasia.

In this study we describe both the systematicity of study and MR findings of tube disease that allow us to limit differential diagnosis and in many occasions get the right diagnosis.

Anatomy of fallopian tubes

Fallopian tubes derive from cranial ends of paramesonephric ducts or Müller’s ducts. They insert into the 2 leaves of the wide ligament superior margin and spread laterally from their supero-lateral margin of uterus to ipsilateral ovary. Each tube anchors itself to its inferior side through a double peritoneal leaf called mesosalpinx opening way to peritoneal cavity.

During the fertile period of life a normal tube is 10 cm long and 1–4 cm wide approx. It has 4 anatomical segments from medial to lateral that are known as: “interstitial or intramural segment” that advances with endometrial cavity and inserted into the myometrium; “isthmus” the narrowest segment—some 2–3 cm long; “ampulla” is the largest and widest segment of all which is >50 per cent the length of the tube; and “infundibulum”. Fimbria are a set of digit-form projections from infundibulum suspended on the ovary opening way to peritoneal cavity and capturing the ovule.

Fallopian tube wall is made up of these layers: mucosa, muscularis externa and serosa. It is complex with longitudinally oriented folds and mucosal folds called plicae both in rising number and size from medial to lateral end. At the intramural portion there are 5 or 6 folds; at the isthmus there are 12 and they are taller and occupy most of the light; in ampulla and infundibulum they are bushier and have secondary and tertiary branches. Mucosal surface has ciliated cells for the ovule to move. Vascular flow comes from uterine and ovaric arteries. Healthy tubes are not usually visible on MR but when they are surrounded by loose liquid, in these cases they look like thin tubular xyyta-uterine structures with anterior-posterior spread.

Magnetic resonance of female pelvis

For a MR study of female pelvis the patient needs to keep a fasting period of 6 h. Then she is placed in the supine decubitus position from head to toe and given spasmoditics via subcutaneous way to reduce artifacts caused by bowel peristaltic movements. Standard protocol to study female pelvis can also be applied to the tubes using surface multi-phase antennas. In our center protocol includes T2-TSE-enhanced high resolution basal sequences in 3 layers and enhanced sequences on T1-TSE on axial level with and without fat saturation. These sequences allow us to identify pelvic dysfunctions and see the relation of tubes to adjacent organs and structures. It also allows a first classification of solid, cystic lesions with hemorrhagic, greasy, proteic, mucus or fibrous content.

If morphological findings are not conclusive and there is suspicion of malignancy or infectious disease IV gadolinium is administered. To assess liquid contrast sequences it is very useful to obtain sequence subtraction images with and without contrast to enhance small uptake focuses especially when focuses are hyperintense and without contrast.

There is also the possibility of using MR to study tube patency through intracavitary gadolinium injection and 3D techniques to replace conventional hysterosalpingography (HSG).

General findings on tube diseases

Most diseases affecting Fallopian tubes can be bilateral so we always need to discard contralateral involvement.

Common presentation of dysfunctional tube is dilation happening when distal end occludes usually at fimbria level to then be filled with liquid. Type of liquid depends on the cause of occlusion. Dilated tube looks like tubular structure separated from ipsilateral ovary in “C” or “S” shape and incomplete septa. These septa correspond to mucosal folds from the tube wall and are partially blurred by distension (Fig. 1). Conversely visible septa at ovaric cystic neoplasms are complete and cross throughout the lesion. Incomplete septa are a very specific sign that tubular structure relates to dilated tube. They are usually thin septa with a very low signal on MRI-enhanced on T2. If folds are very blurred or fibrosed very-well defined hypotense no contrast enhanced wall nodes on T2 can appear. Sometimes there is a huge tube distension and septa can be completely blurred which makes it hard to distinguish between tube with ovaric cystic masses or other structures like dilated ureters or bowel loops. In these cases we need to recognize the tube by its tubular shape and location between uterus and ovaries and identify ovaries as separate unchanged organs.

Tube dilation can be irregular with focal narrowing and tortuous light showing the so-called “peak” sign after formation of an acute angle at the external tube contour when flexing on itself. “Waist” sign appears after formation...
Figure 1  Tubaric obstruction and dilation. Hydrosalpinx: (A) axial T2 TSE. Right tube dilated with hyperintense liquid content of clear water. It contains hypotense (arrow) incomplete septa and areas of focal narrowing--sign of waist--(*); (B) fat saturated axial T1 TSE and IV contrast. Very hypotense liquid content with thin walls and mild regular uptake. Pysosalpinx: (C) axial T2 TSE. Left dilated tube with mild regular uptake and liquid-debris levels (black arrow) and thickened walls. See presence of intraluminal synechia (white arrows); (D) fat saturated axial T2 TSE and IV contrast showing hypotense content with a signal greater than water and walls diffusely thickened and hyperuptake. Hematosalpinx in endometriosis, and (E) axial T2 TSE. Left dilated S-shaped tube (white arrows) with liquid-liquid levels, hyper and hypotense with signal drop in layers (black arrow). Right endometrioimas (*) and deep pelvic endometriosic implant (arrow head); F) fat saturated axial T1 TSE without IV contrast. Content of left tube is hypertense in a homogeneous shape but with a lower signal than water.

Synechiae are identified as thin endoluminal lines hypotensed in all sequences due to inflammatory processes that are not contrast-enhanced.

One of the first considerations to bear in mind is to assess all possible congenital abnormalities or defects. Agenesia or hypoplasia of female genital tract can affect the tubes. Some congenital like imperforate hymen can cause obstruction leading to hematometra and hematosalpinx.

If tube lesion cannot be clearly isolated from ovaries then complex adnexal masses must be included in differential diagnosis.

Characterization of tube content

Study of tube content deals with the type of tubaric lesion and speeding differential diagnosis.

When tube breaks it fills with serum-like liquid and you get a hydrosalpinx and liquid shows the typical MR signal
of water—very hypotense on T1 and very hypertense on T2 (Fig. 1).\(^5\)

Tube dilation with purulent content is known as pyosalpinx. On T1 content signal is variable more commonly low-intermediate though it can be similar or undistinguishable from hydrosalpinx liquid. On T2 signal is heterogeneous and we can have liquid-debris levels creating geographically looking amorphous layers or liquid–liquid levels (Fig. 1).\(^1,5\) Fat saturated sequences and IV paramagnetic contrast are also useful to show other findings associated with tube infection.\(^1,5\)

Hematosalpinx or tubaric dilation with hematic content has a high signal on T1 more evidence in fat saturated images. On T2 signal can be high if bleeding is severe and intermediate-low if it is subacute-chronical due to degradation of hemosiderin.\(^5\) Signal drop can be uniform or in layers (Fig. 1).\(^5\) Hematosalpinx can be due to endometriosis; if that is the case content can be more heterogeneous and the only finding in these patients as well.\(^5,10\) Also it can be secondary to adnexal torsion, ectopic pregnancy, tubaric neoplasm or be associated with abnormalities at Müller’ duct.\(^5,15\)

Tumor at the ‘‘soft endoluminal tissues’’ makes you have to discard neoplasm.\(^5,8,12\) To that end it is very useful to inject IV contrast to see enhanced solid focuses.\(^3-5,16\) Solid mass uptaking contrast whether single or multiple, unilateral or bilateral is supposed to make us suspect of tubaric neoplasm if it is an isolated finding. However it is commonly a metastasis of a gynecological tumor and thus associated with other pathological findings related to primary tumor.\(^7\) Another intraluminal lesion appearing as a parietal node is tubaric endometrial polyp.\(^8\)

Even it is extremely rare that MR can be precise to diagnose ‘‘ectopic pregnancy’’. In the appropriate clinical context RM diagnosis can be done before one dilated tube with parietal thickness and an acute hematoma or with structures of gestational sac inside.\(^3,8\)

**Tube diseases**

**Tube obstruction**

We call hydrosalpinx to the occluded dilated tube but use of this term must be limited to cases where liquid is serum-like liquid. If it gets filled with blood or pus it will be called hematosalpinx and pyosalpinx respectively.\(^7,8,13\)

It can be an isolated finding whether unilateral or bilateral or be associated with ovarian affection creating one complex adnexal mass.\(^8\) As an isolate finding it can be caused by deep pelvic endometriosis or chronic pelvic inflammatory disease (PID) or due to pelvic adherences in cases of former surgery, tube attachment, or simple hysterectomy.\(^1,12\) When there is a complex adnexal mass where tube is included such as the ovary the most likely diagnoses are endometriosis, PID or adnexal tumor lesions usually malignant.\(^8\)

When dilated tube diameter is over 10 cm you can simulate one multiloculated ovarian tumor as for instance one cystadenome or cystadenocarcinome (Fig. 2).\(^5,12\)

**Pelvic inflammatory disease**

It is one of the most common causes of tube disease.\(^12\) It is a sexually transmitted disease affecting female genital apparatus including endometrium, Falloplian tubes, and ovaries unilaterally or bilaterally. Most common agents are *Neisseria gonorrhoeae* (*N. gonorrhoeae*) and *Chlamydia trachomatis* (*C. trachomatis*), but 30–40 per cent of cases is caused by
In initial stages—stage "salpingitis"—tube walls and folds become inflamed, edematous and congestive. Magnetic resonance shows these with a high degree of variable dilation and thick walls enhanced from moderate to intense with IV contrast. Ovaries stay normal and separated from them (Fig. 3).

Polimicrobians. Infection by Actinomyces and Mycobacterium tuberculosis (M. tuberculosis) is a rare cause of PID but when it occurs it usually causes tubo-ovarian abscesses rather than a simple tube disease.

Tube affection due to these infections can cause infertility, pelvic pain or peritonitis and increase the risk of ectopic pregnancy.

When PID presentation is acute and typical clinical analytical diagnosis and through endovaginal ultrasound are usually enough. Computed tomography is useful to assess inflammatory signs and abscesses associated and if they need to be drained in a clinical emergency context mainly. However in cases of atypical presentation, atypical cases, or presentation in subacute-chronic stages when there is suspicion of complications for lack of response to therapy or in presence of complex adnexal masses, MR is very useful for diagnosis. It is key to diagnose and treat PID on time because of the risk potential of irreversible affection on the tubes.

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If disease progresses adherences around fimbria blocking the tube will appear. Pus accumulates in light causing pyosalpinx with peritubal and/or ovarian inflammation. In this suppurative status besides identifying pyosalpinx, MR can show ingurgitation of vascular pedicle and fat striation in a network-shape showing some thickness and pelvic peritoneal enhancement.

When infection reaches the ovary in the beginning both the tube and the ovary can show some inflammatory changes but remain separated. This stage is known as "salpingo-oophoritis". From this moment on ovaries become inflamed, increase their size and blur their contours. As tissues destroy a complex adnexal mass pops up in which both organs cooperate. If process evolves even further we will have a "tube-ovarian abscess" (Fig. 4).

Magnetic resonance distinguishes between complex adnexal mass of thick walls, irregular internal contours, heterogeneous liquid content, and a variable number of internal septa and gas or liquid-liquid levels. This liquid can be proteic or hemorrhagic with a high signal on T1 and one heterogeneous signal on T2 usually high depending on viscosity and proteic content. This mass is usually surrounded by a poor defined area of high signal on T2 by edema and exudates. Ring has been seen at the internal mass portion uptaking contrast in an intense way corresponding to granulated tissue with hemorrhagic remains. Mass involvement from other
non-gynecological organs like thin bowel loops, ureters or bladder.\textsuperscript{20}

Up to 20 per cent of tube-ovaric abscesses can present as symptoms or clinical signs contemplating the possibility of differential diagnosis with benign and malignant adnexal neoplasms.\textsuperscript{20} MR is useful to diagnose, follow-up and monitor the involution of findings after therapy (Fig. 3).\textsuperscript{19} It is important to establish the right therapy since rupture of a tube-ovaric abscess can cause serious peritonitis.\textsuperscript{1}

Other uncommon causes of tube-ovaric abscesses are actinomycosis—usually chronic, pelvic tuberculosis (TBC), and adnexal xanthogranulomatous inflammation. These 3 variants are harder to distinguish from ovarian neoplasms but since they can be managed through medical therapy only it is very important to get to know them.\textsuperscript{23}

Chronical infection by \textit{Actinomyces israelii} (\textit{A. israelii}) is associated with chronic use of intrauterine contraceptive devices and is treated efficiently with high doses
Figure 5  Bilateral tubaric endometriosis: bilateral hematosalpinx; 50-year-old postmenopausal woman with abdominal pain and elevation of CA-125. (A) Axial T2 TSE; (B) sagittal T2 TSE; (C) T1 axial TSE with fat suppression, and (D) axial T1 TSE with fat suppression and IV contrast. Tube dilation (arrows) with irregular parietal thickening and liquid–liquid levels. On T2 sequences content in declined areas is hypotense (*) and on T1 both this focus and walls of both tubes are hyperintense. With contrast walls are intensely enhanced.

Isolated fallopian tube torsion

Isolated tube torsion—the torsion not associated with an ovarian abnormality is one uncommon cause of acute pelvic pain requiring MR for diagnosis in rare occasions. Rapid diagnosis with early surgery can prevent irreversible vascular damage on the tube. When in doubt MR is only used to distinguish it from certain neoplasms.

It is more common in young fertile women and is associated with a long or congested mesosalpinx, prior PID or tube linkage, tube hypermobility or trauma. Some cases in girls have also been reported. Other than distinguishing one normal ovary though MR we should be able to identify a thick walled-dilated tube with spiral configuration or areas of parietal infarct without contrast uptake and intraluminal hemorrhagic content.

Endometriosis

Up to 30 per cent of women with endometriosis on laparoscopy have tube abnormalities associated. Patients can be asymptomatic or present with chronic pelvic pain, infertility or dipareunia.
Figure 7  Right primary tubaric neoplasm (endometroid adenocarcinoma); 73-year-old woman with some bleeding (spotting) and no elevation of tumor markers. (A) Coronal T2 TSE; (B) axial T1 TSE with fat suppression and (C) axial T1 TSE with IV contrast. Tubular solid mass on right adnexal region (*), heterogeneous on T2 sequences. On fat suppressed-T1 TSE mass shows signal stronger than muscle and smoothly and homogeneously enhanced after IV paramagnetic contrast. Atrophic ovaries.

Figure 6  Endoluminal endometriosis; asymptomatic 26-year-old woman. (A) Coronal T2 TSE; (B) axial T1 TSE with fat saturation; (C) T1 subtraction with and without IV contrast, and (D) hysterosalpingography (HSG). Left dilated tube with acute hemorrhagic content, hyperintense on T1 and T2 with endoluminal node lesion depending on the wall that is enhanced (arrows). HSG confirmed endoluminal location of node lesion and patency of affected tube. Anatomopathology confirmed the endometriotic origin of popypoid lesion.
Fallopian tube disease on magnetic resonance imaging

Tube affection by endometriosis is an isolated finding as hydro or hematosalpinx or as part of a complex pelvic mass if there are deep pelvic endometriotic cysts and/or implants affecting both tubes and ovaries.\(^{29,30}\) Depending on where implants are located there are 2 main ways of tube affection: serose–subserose and intraluminal.\(^1,8\)

Serose and subserose endometriosis is due to implantation of functioning endometriotic tissue focuses on the peritoneal surface of the tube.\(^1\) Implants cause repeated intraluminal hemorrhages that occasionally cause formation of fibrous tissue and afterwards peritubal adherences causing tubal obstruction (hydrosalpinx and/or hematosalpinx)\(^1,8\) (Fig. 1). Isolated hematosalpinx can be the only finding in certain patients with unknown history,\(^10,29\) but there are other more common signs of endometriosis at pelvis level. Content of the affected tube has a very high signal on T1 but not always the signal diminishing effect on T2 (T2 shading) typical of endometriomas.\(^8\) On some occasions debris at the portion depending on the tube or hemorrhagic remains that only cover the walls can be identified (Fig. 5).

Endoluminal endometriosis is much less common. It is caused when endometrial tissue on the mucosal surface is found usually from the interstitial portion of the tube.\(^1\) This endometrial tissue is made up of endometrial glands and stroma and does not get to invade the smooth muscle layer.\(^31\) Implants cause small intraluminal polyloid nodes–usually

**Figure 8** Bilateral primary tubaric neoplasm. Asymptomatic 51-year-old woman. (A) Coronal T2 TSE; (B) axial T2 TSE; (C) coronal T2 TSE; (D) axial T1 TSE with fat suppression, and (E) axial T1 TSE with fat suppression and IV contrast. Both tubes are dilated with hypertense content on T1 (\(^*\) in D showed right only) with small nodes, multiple and bilateral–enhanced by contrast (arrows). Normal ovaries and uterus with no significant adenopathies. Anatomopathological study diagnosed a bilateral primary serous adenocarcinoma with multiple endoluminal implants together with a gelatinous hematic liquid-tubaric content.
<1 cm and invisible on MRI. They are usually found as well-bounded round repletion defects on HSG. However in some cases you can see a parietal node on the MRI (Fig. 6). When in doubt on its intraluminal location it is good to do a HSG. The endoluminal form is not associated with tubaric occlusion or dilation if it presents as an isolated finding even though it can be caused by repeated intraluminal hemorrhage. Also it can be associated to other signs of pelvic endometriosis too. Serose–subserose type can be unilateral or bilateral and gets to cause symptoms of infertility rarely.

Primary malignant tube neoplasm

Fallopian tubes primary malignant neoplasm is very uncommon—seen in 0.4–1.8 per cent of all gynecological cancers. However its incidence might be underestimated because histologically speaking it is hard to distinguish tube primary tumors from epithelial ovarian carcinomas since both are identical, especially in advanced stages. It is more common in postmenopausal women at their 4th and 6th decades of life with an incidence peak at 55 years. Most are papillary serose type of adenocarcinomas mainly and usually unilateral even though 20 per cent of cases are bilateral.

Even though inespecific for diagnosis in up to 80 per cent of cases serum CA-125 assay will be high. It is a useful independent prognostic marker to assess clinical response to therapy and detect recurrences even before clinical or radiological representation.

From early stages they can by asymptomatic or cause inespecific symptoms like pain for tubaric distension and leukorrhea or vaginal bleeding. Some times it can present like a palpable mass. These manifestations urge patients to look for medical assistance sooner than later—this is why tubaric cancer is usually detected in stages earlier than ovarian cancer where manifestations present a little later. However because if its small size at the beginning and frequency of presentation, clinical and eco-graphical diagnosis is usually hard and this is because an MRI of pelvis with IV contrast can be very useful.

Tumor growth pattern can be nodular, papillar, infiltrative or invasive. They usually originate in the ampullary region and grow toward tubaric light. Depending on secretions caused they trigger tubaric dilation or not but the most common is them secreting a huge load of serous liquid.

If they do not cause hydrosalpinx they are identified as small tubular masses uptaking contrast and they can contain cystic areas by necrosis o hemorrhage (Fig. 7). If tumor causes liquid secretions and fimbria are occluded we have a hydrosalpinx. In these cases lesion is a tubular tortuous solid-cystic mass. This tubular configuration is the key to diagnosis and lead us to suspect that tumor originates in the tube, not the ovary. Occasionally it presents with nodes or single or multiple papillae in the light of dilated tube (Fig. 8). It can present as a dented wheeled-multipolar cystic structure as well as a result of a tube fold dilated on itself. This look makes it hard to distinguish the typi-cal tubular configuration that leads to a tubaric tumor and radiologically it is undistinguishable from an ovarian tumor if ovary is not overtly separated from the mass. It is important to bear in mind that ovarian tumors can spread locally toward the tubes which makes the origin of tumor hard to distinguish (Fig. 9). If fimbria are occluded or the result of occasional decompressions after painful episodes intrauterine liquid or peritumoral ascitis will be associated. Intraperitoneal dissemination is similar to ovarian cancer and its ganglionar or metastasic dissemination is more common than its ganglonar or metastastic dissemination.

Tumor solid component presents in MR both looking homogeneous and heterogeneous—usually iso- or hypertense...
on T2 and hypotense on T1 with an evident contrast uptake. Liquid associated will be clear, hyperintense on T2 or hemorrhagic, hyperintense on T1. MR is also useful for a local presurgical stratification whose determinant limits according to the International Federation of Gynecology and Obstetrics (IFGO) are the exclusive affectation of one of the 2 tubes and the extension to serose or peritoneal affectation other than the presence of metastasis.

Differential diagnosis includes primary ovaric tumors with or without spreading toward the tube and metastases mostly those due to direct spreading from other gynecological tumors.

When there is suspicion of tubaric neoplastic affectation we will always have to discard other primary tumor of gynecological origin (endometrial and ovaric) given the high frequency of these tumors. If bilateral affectation occurs it is usually hard to distinguish between bilateral primary and unilateral primary associating contralateral metastasis.

In rare occasions a tubaric mass is due to a tube primary myoma. If so a small fusiform well-defined mass located between ovary and uterus will be identified but separated from the two behaving on MR exactly the same as uterine myomas.

Exclude other pelvic dysfunctions

Pelvic alterations in women are not gynecological only. In differential diagnosis we need to include other diseases when normal ovaries are identified. Tubaric diseases need to be distinguished from other entities causing paraovaric lesions with liquid content like paraovaric cysts, peritoneal inclusion cysts, lymphangiomas, lymphoceles, and appendicular mucocles among others.

Conclusion

MR is a very accurate technique to diagnose diseases of Fallopian tubes with values of specificity and sensibility superior to those of ultrasound and CT which makes it especially useful for tubaric alterations with atypical or complex presentation. Insight of tubaric pathology and its findings on MR gives the radiologist an important role in the diagnostic algorithm of tubaric diseases both to get a precise diagnosis and define differential diagnosis as much as possible.

Ethical responsibilities

Human and animal protection. Authors declare that for this research they have not done any experiments on human beings or animals.

Data confidentiality. Authors declare that the article does not show the names of patients.
Privacy right and informed consent

Authors declare that the article does not show the names of patients.

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