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Microwave Ablation of Benign Breast Lesions: An Initial Study

Huynh Quang Khanh and Tran Quyet Tien*

Department of Breast, Cho Ray Hospital, Ho Chi Minh City, Vietnam

Abstract

Background: To evaluate the safety and efficiency of Microwave Ablation (MWA) in the treatment of benign breast tumors and cysts.

Methods: 41 patients with a total of 64 benign breast tumors and cysts underwent MWA. Patients were followed up from August 2018 to September 2019.

Results: The average diameter of these lesions was 2.8 ± 0.6 cm (1.5 cm to 4.0 cm). MWA was performed with the medium 2.4 min (0.5 min to 7.5 min). Outcome of MWA treatment which was check by ultrasound imaging revealed that 100% of cystic lesions and 85% of tumor lesions were complete response, 15% of benign tumors were partial response during monitoring. And 100% of patients rated excellent about post-ablative aesthetics. There was no side effect, relapse or malignancy during follow-up.

Conclusion: This study shows that the application of MWA to benign breast tumors and cysts is feasible and highly efficient. Symptoms and size of lesions are significantly reduced after treatment. At the same time, fast resilience and aesthetic are guaranteed.

Keywords: Benign breast lesions; Breast tumors and cysts; Microwave ablation

Introduction

Fibrocystic breast changes, includes fibroadenomas, fibrosis and papillomas, are the most common types of benign breast tumors [1]. The changes in fibrocystic breast disease cause lumpy breast tissue. These lumps are smooth with well-defined edges and free-moving. The number of these tumors is varying from patient to patient. There can be one or many lumps on both sides of a woman breast. Fibrocystic changes are common in women, especially in the ages of 20 to 40 [1].

Breast cysts are fluid-filled sacs in breast tissue, which are usually found in the upper sections of right and left breasts. Breast cysts are common in preimenopausal women, incidence peaks between ages of 35 and 50 years [2]. In the case of taking hormone replacement therapy, cysts can be found in post-menopause stage [3].

Fibrocystic breast changes and breast cysts should be monitored. However, beside of small lesions with few symptoms, some large lesions cause pain, breast tenderness and redness, especially when they have multiple infections or abscesses. Therefore, benign lesions sometimes require treatment due to subjective symptoms and aesthetics concerns.

Traditionally, fibrocystic changes are treated by resection. This procedure often causes pain, excessive blood loss, and large scars. As for breast cysts, there are two types of treatment:

(i) Fine-needle aspiration method is used to treat small cysts, but it is easy to replace;

(ii) Cysts removal surgery is usually applied for large cysts, but it causes pain and scars.

Minimally invasive surgery, an alternative method to ablate benign breast tumors and cysts, has become more popular. Recently, Microwave Ablation (MWA) has been proposed to resection kidney, liver and lung tumors. This technique involves the emission of electromagnetic microwaves from needle-like antennas into the target tissue. Kinetic energy associated with the subsequent agitation of water molecules creates a hot area in the surrounding tissue [4]. This treatment method has lots of advantages, such as reducing treatment time and cost, less toxicity, less heat sink effect and providing larger ablation zone [5]. Improvements in ablation technology also help to reduce morbidity and mortality [6]. Combined with imaging technique (ultrasound), image-guide ablation

Correspondence:
Huynh Quang Khanh, Department of Breast, Cho Ray Hospital, 201B, Nguyen Chi Thanh, Ward 12, District 5, Ho Chi Minh City, Vietnam, Tel: +84908115780; E-mail: khanhhuynhquangphd@gmail.com

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provides an ability to determine and control the ablation zone, which has become a good option for patients. Moreover, this less invasive procedure can be done in outpatient setting, which is more convenient for both patient and healthcare system [7].

Despite the advantages of image-guided MWA, research on its application in the treatment of breast lesions is limited [8], especially in Vietnam. This article is an initial study of using image-guided MWA to treat benign breast tumors and cysts in breast department of Cho Ray Hospital, Vietnam. The safety and efficiency of MWA technique in benign breast tumors and cysts ablation will be determined throughout this study.

Methods

Patient selection

This study was conducted within 12 months, from August 2018 to September 2019 at Breast Department, Cho Ray Hospital. Patients were explained the contents, purpose of this study and agreed to participate. Sample collection procedure was slightly different between tumors and cysts. Tumor specimens were collected by core-biopsy and sent for histopathology examination. Only tumors shown benign results were selected for following up in this study. As for breast cysts, Fine-Needle Aspiration (FNA) technique was applied to collect all their fluid to send for cystology examination. Only benign large cysts (diameter ≥ 1 cm) with symptomatic or relapse were recorded for further study. Besides, all samples collected from patients whom were under menstruation period or breastfeeding were rejected.

Treatment procedure

Patient preparation: Breast cysts and tumors were located by ultrasound. After determining the safest and easiest approach, patient was placed according to the position of their tumors or cysts to prepare for ablation. Patient's skin was disinfected in large-scale with alcohol. A sterilized cloth was spread to reveal the operating area. Local anesthesia was done by injecting 2 ml lidocaine 2% subcutaneously. Areas around the lesion were anesthetized as well. Diluted anesthetic or saline could be used to separate cysts or tumors which located near sensitive organs, such as skin, pectoral muscle, nipple, etc.

Microwave ablation: Microwave ablation was performed by using Medwaves Systems (Figure 1) and was done according to the procedure of Xu et al. [9]. Antenna type was selected to suit the size of cyst or tumor (Table 1). To prevent skin burns, temperature was set at 70°C, and the heating time was around 1 min to 3 min. Additionally, a wet swab was placed at the puncture site, and it was kept continuously moist during the ablation. Saline or diluted anesthetic could be administered subcutaneously at antenna site. As mentioned above, FNA was conducted on breast cysts before ablation. Firstly, an antenna was inserted into the center of a cyst. Secondly, a fine-needle was used to draw all the fluid out while remaining the antenna in its position. Finally, MWA was performed to ablate completely. A specimen of cyst fluid was sent for cystology examination.

On the other hand, histopathology examination was required before ablation procedure to make sure the tumor was benign. An antenna was inserted through breast tissue to reach the lesion. It can be re-inserted repeatedly to ensure the ablation zone covered the entire tumor and surrounding tissues were less damaged.

Virtual signs, symptoms of pain, vomiting, fatigue and shortness of breath were monitored throughout the process. In case Fentanyl could not control patient pain or server complications occurred, the procedure must be discontinued.

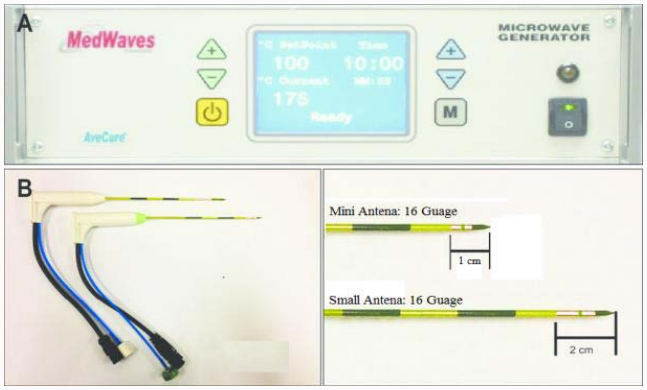

Figure 1: Microwave generator and needle antenna.

Table 1: Types of antenna.

Type	Gauge	Length	Maximum ablation area	
			Width	Length
Large	14	4 cm	5.0 cm	6.0 cm
Small	16	2 cm	2.5 cm	3.0 cm
Mini	16	1 cm	1.3 cm	1.4 cm

Monitoring after treatment: Patients were kept for follow-up within 24 h after treatment. Virtual signs were recorded hourly in the first two hours, and every three hours after that. Symptoms after ablation, such as pain, fever, fatigue, nausea, dizziness, shortness of breath…, were recorded and managed. In case of complication testing and imaging diagnosis were carried out to identify and handle as soon as possible. Post-ablative lesions after 1 week, 3, 6, and 12 months are examined by ultrasound.

Outcome evaluation of MWA treatment is evaluated in 02 stages: Early stage and follow-up stage. As for early stage, safety is the most concerned matter. Safety assessment bases on the rate of mortality and complication (hematoma, skin burns, pain, and losing sight of lesion…) during and 24 h after treatment. Besides, aesthetics and patient satisfaction are also considered as evaluation criteria in the early stage. As for follow-up stage, therapeutic efficacy is evaluated at 3, 6 and 12 months because lesion size (longest diameter) continues to decrease during 1 year after ablation [10]. Therefore, therapeutic efficacy is evaluated at 3, 6 and 12 months. Evaluation criteria of therapeutic efficacy are detailed in Table 2. The follow-up procedure would be discontinued when the case was considered Complete Response (CR). Partial response and stable disease cases should be monitored until reaching CR stage or until 12 months.

Results

64 benign tumors and cysts, found in 41 women, were ablated by ultrasound-guided MWA. The average age was 45.71 ± 12.36, the youngest was 24 and the oldest was 73 years old. The average size of tumors and cysts was 2.8 ± 0.6 cm, 1.5 cm was the smallest and 4.0 cm was the largest. Table 3 shows the distribution of lesions in patients and their characteristics. Meanwhile, lesion positions are listed in Table 4. There was 1 case (2.4%) of anesthetic allergy, which was detected promptly. This patient had been treated as an anaphylactic case and was back to stable stage. Although the procedure was discontinued, the ablation had been completed previously. Besides, there were 2

Table 2: Evaluation criteria of therapeutic efficacy.

Response categorization	Post-ablative lesion	
	Decrease in the longest diameter[a]	Other signs on B/W ultrasound imaging
Complete response (CR)	>80%	N/A
Partial response (PR)	≥ 20% and ≤ 80%	Central necrosis or central acoustic cavitation
Stable disease (SD)	<20%	Dense
		No sign of central necrosis or cavitation

[a]Compare with pre-ablative lesion.

Table 3: Lesion characteristics and distribution in patients (n=41).

		Quantity	%
Distribution in patients	Both breasts	23	56.1
	Left breast	12	29.3
	Right Breast	6	14.6
Lesion Characteristics	Benign cyst	27	65.9
	Benign tumor	14	34.1
	BIRADS 2	27	65.9
	BIRADS 3	13	31.7
	BIRADS 4	1	2.4

Table 4: Lesion positions (n=64).

	Quantity	%
1 Lesion[a]	18	28.1
2 Lesions[a]	41	64.1
3 Lesions[a]	3	4.7
4 Lesions[a]	2	3.1
Superficial lesion	7	10.9
Close to pectoral muscle	9	14.1
Close to the areola	11	17.2
In breast tissue	37	57.8
Palpable	59	92.2
Nonpalbale	5	7.8

[a]Number of lesions on one side of the breast

patients (4.8%) felt pain during ablation because their lesions located close to the chest wall. Anesthetic was injected to separate the tumor from the chest wall. Then MWA was done successfully. Also, in the case of the longest ablation time (2.4%), the puncture site became hot, which had to be settled by local anesthesia. This case was completed with no skin burn. Although there are some patients whose lesions located near the skin or the areola, all ablation cases did not cause any skin burn. There was no losing track on ultrasound due to a large amount of local anesthetic, or case of post-ablative bleeding or hematoma. The average monitoring time was 8 months, the shortest was 3 months and the longest was 12 months. The number of palpable lesions decreased from 59 to 4 after ablation. In the other words, the rate of non-palpable lesion increased from 7.8% to 85.9%.

The response to MWA was checked by ultrasound imaging: 100% of cysts and 85% of benign tumors were complete response, 15% of benign tumors were partial response during monitoring. Every patient (100%) rated excellent about post-ablative aesthetics. There was no side effect, relapse or malignancy during follow-up.

Discussion

To minimize pain, bleeding and scarring, minimally invasive technology combined with image-guide becomes a potential method in breast lesion surgery. However, most of recent studies focus on malignant lesion ablation [11-16]. Only a few researches mention about applying MWA on benign breast tumors [9,10,17].

In this initial study, the advantages and disadvantages of MWA method are evaluated based on two factors: The first one is method of implementation, such as antenna size, microwave energy selection; the second one is possible complications and safety level. We also discuss how to deal with some common complications in this paper.

Antenna size and microwave energy selection

In our study, small antennas are often used for lesions larger than 2 cm, and mini antennas for lesions smaller than 2 cm.

There are two modes for energy selection: temperature mode and energy mode. Xu et al. [9], Zhang et al. [10] and Yu et al. [17] used energy mode to maintain the energy at 30W, 40W and 28.3W, respectively. Thus, leads to temperature variation during ablation. In our study, we used temperature mode to maintain the target temperature. Basically, temperature between 46°C and 60°C causes cell necrosis and irreversible tissue changes, proportional to the exposure of time, whereas temperature between 60°C and 100°C causes immediate cell death [18]. Therefore, ablation temperature should be around 60°C to 100°C. However, due to thermal conductivity, if the target temperature is too high, skin burn (at the puncture site) will occur easier and sooner. In contrast, the ablation time will be longer if the target temperature is too low. In this study, we set the target temperature at 70°C to destroy tumor cells completely and avoid skin burns.

Total 64 benign lesions, found in 41 patients, were ablated by MWA, under the guidance of ultrasound. The average size of tumors and cysts was 2.8 ± 0.6 cm, 1.5 was the smallest and 4.0 cm was the largest. The average ablation time was 2.4 min, the shortest was 0.5 and the longest was 7.5 min. Lesions were completely ablated in all cases (100%) without any skin burn.

In the research of Yu et al. [17] 198 lesions, found in 122 patients, were ablated by MWA with the average energy was 28.3 ± 6.2 W and the average ablation time was 3.2 min. Lesions were ablated completely in 99.5% cases. 01 large lesion (3.6 cm) was partial ablated.

Zhang et al. [10] also used MWA to ablate 205 benign breast lesions, found in 182 patients. The energy was set at 40W in all cases, and lesions were ablated completely in 87.32 % of cases evaluated by contrast-enhanced ultrasound.

Possible complications and safety level

In this paper, we would like to mention about some common complications that occur during and after breast lesion ablation by MWA, such as skin burns, pain, hematoma and losing track on imaging.

There are two reasons that cause skin burns. The first one is thermal conductivity on the antenna. Heat generated from the tip

is conducted to the entire antenna, which might cause skin burns at the puncture site. As mentioned, to prevent skin burns from thermal conduction, ablation temperature should be set around 70°C. In addition, it is necessary to place disinfected gauzes around the puncture site, and it should be kept moist by continuously apply saline diluted anesthetic. A biopsy needle could be used as guidance, and then the antenna would be insert into the biopsy needle to isolate the antenna from the skin. Also, position of ablation zone may cause skin burns. As for superficial lesions, the ablation will also heat all tissues in its zone, causing skin burns. Therefore, anesthetic should be injected to separate the lesion away from the skin.

In order to avoid pain, puncture site and area around the target lesion should be well anesthetized. Fentanyl is necessary for sensitive patients. However, injecting a large amount of anesthetic may cause losing track on ultrasound. Therefore, too much anesthetic should not be injected at the superficial site of a lesion, and its image on ultrasound should be monitor continuously while injecting.

Besides the complications that happen during ablation as mentioned, hematoma is a post-ablative complication. To prevent this phenomenon, it is necessary to determine the exact location of target tumor or cyst; antenna re-inserting should be limited as well. Furthermore, compress bandage after ablative is required.

In this study, there were 03 cases (7.2%) in which patients felt pain during ablation. Superficial lesions and long ablation time are the cause of pain. Adding anesthetist was our solution. However, as mention above, anesthetics should be adjusted: too little might cause pain, too much might cause artifacts on ultrasound. There were no other complications.

Especially, there was 01 case (2.4%) that patient was allergic to anesthetics. The allergic condition of this patient was discovered in her medical history. However, pre-ablative test result did not record allergic reaction. In this case, a procedure to prevent allergy had been repaired before ablation. Allergy symptoms appeared when the procedure was almost done, at which point the lesion had been completely removed. Patient's post-ablative condition was stable, there was no severe progression.

Overall, all patients in our study were well tolerated pain and burning sensation during ablating. There was no complication. Our result is similar to the research of Yu et al. [17]. In the research of Zhang et al. complications, such as mild pain, skin redness and swelling, duct dilation and fat liquefaction, appeared during and after the ablation in 69 cases (38%). However, these complications were relieved or disappeared after the symptomatic treatment [10].

Patients were followed up after ablation for 3 to 12 months, depending on their post-ablative response. The average follow-up period was 8 months. Palpable lesions decreased from 59 (92.2%) to 04 (6.3%). After an average of 14 months follow-up, the rate of palpable lesions in the research of Yu et al. [17] decreased from 90.2% to 45.9%, which is higher than ours. Ultrasound imaging revealed that 100% of cystic lesions and 85% of tumor lesions were complete response, 15% of tumor lesions were partial response during follow-up. This rate is higher than the research of Zhang et al. [10]. As for post-ablative aesthetics, 100% of patients felt satisfied. There was no side effect or relapse or malignancy.

The advantages and disadvantages of benign breast lesions ablation by using MWA technique

Breast is an organ which lies in a superficial layer of woman's skin. Unlike liver, kidney or thyroid…, there is no important vascular structure in the mammary gland. Therefore, breast is the most suitable organ to apply MWA technique to ablate lesions.

The advantage of microwave ablation technique is minimal invasive, which requires local anesthesia only. In addition, the use of fine-needle, 16G, helps to intervene multiple lesions at once without damaging or deforming the breast. In addition to fast implementation, this technique does not leave scars on the skin, ensuring aesthetic for patients.

The disadvantage of MWA in treating breast lesions is the determination of benign or malignant nature of a lesion. A small sample taken by a fine needle is easy to show false-negative results [19]. This leads to difficulties in post-ablative monitoring process. To overcome this limitation, histopathology examination is needed. Vacuum-assisted Breast Biopsy (VABB) is one of the alternative methods for obtaining larger samples. However, it may cause damage to breast tissue because of the use of large needles (8G, 10G), especially in cases of multiple or large lesions [20]. Therefore, the method of core biopsy *via* core guide is preferred. A core guide is placed in the lesion to perform core biopsy. Then, an antenna will be brought to the lesion through this core guide to perform MWA. This method not only helps to avoid skin burns at the puncture site but also minimizes needle re-inserting, which damages healthy breast tissues. Partial response is also disadvantage point in using MWA. Patients may feel nervous and unsatisfied because there is still a palpable lesion after the procedure.

Conclusion

This study shows that the application of MWA to benign breast tumors and cysts is feasible and highly efficiency. Symptoms and lesion size are significantly reduced after treatment. At the same time, fast resilience and aesthetic are guaranteed.

Ablating benign breast tumors and cysts using MWA is a new technique. Although there are some limitations, the benefits of this method are significant. It is a minimally invasive technique that can remove benign breast tumors and cysts completely without surgery. It does not cause severe pain or blood loss, and leaves no scars. MWA technique offers a good alternative treatment method for breast lesions. Research on MWA technique can be extended to patients with malignant lesions.

Ethical Statement

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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