ISSN 2307-8960 (online)

World Journal of *Clinical Cases*

World J Clin Cases 2022 January 14; 10(2): 397-752

Published by Baishideng Publishing Group Inc

World Journal of Clinical Cases

Contents

Thrice Monthly Volume 10 Number 2 January 14, 2022

EDITORIAL

MINIREVIEWS

ORIGINAL ARTICLE

Case Control Study

Retrospective Study

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 2 January 14, 2022

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 2 January 14, 2022

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 2 January 14, 2022

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 2 January 14, 2022

Contents

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Associate Editor of *World Journal of Clinical Cases*, Bruno Ramos Chrcanovic, DDS, MSc, PhD, Associate Professor, Department of Prosthodontics, Malmö University, Malmö 241 21, Sweden. bruno.chrcanovic@mau.se

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RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Jia-Hui Li*; **Production Department Director:** *Xu Guo*; **Editorial Office Director:** *Jin-Lei Wang*.

NAME OF JOURNAL
World Journal of Clinical Cases

ISSN
ISSN 2307-8960 (online)

LAUNCH DATE
April 16, 2013

FREQUENCY
Thrice Monthly

PUBLICATION DATE
January 14, 2022

World Journal of Clinical Cases

Submit a Manuscript: https://www.f6publishing.com

World J Clin Cases 2022 January 14; 10(2): 485-491

DOI: 10.12998/wjcc.v10.i2.485

ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Retrospective Study

Combined molybdenum target X-ray and magnetic resonance imaging examinations improve breast cancer diagnostic efficacy

Wen-Quan Gu, Sun-Mei Cai, Wei-Dong Liu, Qi Zhang, Ying Shi, Li-Juan Du

ORCID number: Wen-Quan Gu 0000-0003-0810-3736; Sun-Mei Cai 0000-0001-9593-652X; Wei-Dong Liu 0000-0002-1767-8286; Qi Zhang 0000-0001-6735-3642; Ying Shi 0000-0002-2853-2602; Li-Juan Du 0000-0003-1431-5129.

Author contributions: Gu WQ and Du LJ designed the research study; Cai SM and Zhang Q performed the research; Yang CH contributed new reagents and analytic tools; Gu WQ and Cai SM analyzed the data and wrote the manuscript; all authors have read and approve the final manuscript.

Institutional review board statement: The study was reviewed and approved by the Punan Hospital Institutional Review Board.

Informed consent statement: All study participants provided informed written consent prior to study enrollment.

Conflict-of-interest statement: No conflict of interest.

Data sharing statement: No additional data are available.

Supported by Clinical Plateau Department, Shanghai Pudong New Area Health Construction Commission, No. PWYgy2018-04.

Wen-Quan Gu, Sun-Mei Cai, Wei-Dong Liu, Qi Zhang, Ying Shi, Li-Juan Du, Department of Radiology, Punan Hospital, Shanghai 200126, China

Corresponding author: Li-Juan Du, MHSc, Attending Doctor, Department of Radiology, Punan Hospital, No. 279 Linyi Road, Shanghai 200126, China. haomiao2010@126.com

Abstract

BACKGROUND

Early-stage breast cancer patients often lack specific clinical manifestations, making diagnosis difficult. Molybdenum target X-ray and magnetic resonance imaging (MRI) examinations both have their own advantages. Thus, a combined examination methodology may improve early breast cancer diagnoses.

AIM

To explore the combined diagnostic efficacy of molybdenum target X-ray and MRI examinations in breast cancer.

METHODS

Patients diagnosed with breast cancer at our hospital from March 2019 to April 2021 were recruited, as were the same number of patients during the same period with benign breast tumors. Both groups underwent molybdenum target X-ray and MRI examinations, and diagnoses were given based on each exam. The single (*i.e.*, X-ray or MRI) and combined (*i.e.*, using both methods) diagnoses were counted, and the MRI-related examination parameters (*e.g.*, T-wave peak, peak and early enhancement rates, and apparent diffusion coefficient) were compared between the groups.

RESULTS

In total, 63 breast cancer patients and 63 benign breast tumor patients were recruited. MRI detected 53 breast cancer cases and 61 benign breast tumor cases. Molybdenum target X-ray detected 50 breast cancer cases and 60 benign breast tumor cases. The combined methodology detected 61 breast cancer cases and 61 benign breast tumor cases. The sensitivity (96.83%) and accuracy (96.83%) of the combined methodology were higher than single-method MRI (84.13% and 90.48%, respectively) and molybdenum target X-ray (79.37% and 87.30%, respectively) ($P < 0.05$). The combined methodology specificity (96.83%) did not differ from single-method MRI (96.83%) or molybdenum target X-ray (95.24%) ($P > 0.05$). The T-wave peak (169.43 ± 32.05) and apparent diffusion coefficient (1.01 ± 0.23) were

Country/Territory of origin: China

Specialty type: Radiology, Nuclear Medicine and Medical Imaging

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification
Grade A (Excellent): 0
Grade B (Very good): B, B
Grade C (Good): 0
Grade D (Fair): 0
Grade E (Poor): 0

Received: September 9, 2021
Peer-review started: September 9, 2021
First decision: October 18, 2021
Revised: October 19, 2021
Accepted: December 3, 2021
Article in press: December 3, 2021
Published online: January 14, 2022

P-Reviewer: Izuegbuna OO, Mazurek A
S-Editor: Wang JL
L-Editor: A
P-Editor: Wang JL

lower in the breast cancer group than in the benign tumor group (228.86 ± 46.51 and 1.41 ± 0.35, respectively). However, the peak enhancement rate (1.08 ± 0.24) and early enhancement rate (1.07 ± 0.26) were significantly higher in the breast cancer group than in the benign tumor group (0.83 ± 0.19 and 0.75 ± 0.19, respectively) ($P < 0.05$).

CONCLUSION
Combined molybdenum target X-ray and MRI examinations for diagnosing breast cancer improved the diagnostic sensitivity and accuracy, minimizing the missed- and misdiagnoses risks and promoting timely treatment intervention.

Key Words: Molybdenum; X-rays; Magnetic resonance imaging; Breast neoplasms; Early diagnosis; Radiology

Core Tip: Early-stage breast cancer patients often lack specific clinical manifestations, making diagnosis difficult. Molybdenum target X-ray and magnetic resonance imaging examinations both have advantages. Thus, a combined examination methodology may improve early breast cancer diagnoses. This study explored the combined diagnostic efficacy of molybdenum target X-ray examinations and magnetic resonance imaging for breast cancer. The combined methodology improved the diagnostic sensitivity and accuracy, minimizing the missed- and misdiagnoses risk and promoting timely treatment intervention.

Citation: Gu WQ, Cai SM, Liu WD, Zhang Q, Shi Y, Du LJ. Combined molybdenum target X-ray and magnetic resonance imaging examinations improve breast cancer diagnostic efficacy. *World J Clin Cases* 2022; 10(2): 485-491
URL: https://www.wjgnet.com/2307-8960/full/v10/i2/485.htm
DOI: https://dx.doi.org/10.12998/wjcc.v10.i2.485

INTRODUCTION

Breast cancer can present as multiple malignancies, and recently, the incidence and morbidity are increasing in younger populations[1]. Early-stage breast cancer patients often lack specific clinical manifestations, and without timely diagnosis and intervention, the disease may progress, potentially invading the skin and the thoracic muscles and fascia. For some, undetected malignancies result in lymphatic and distant metastases, which are life-threatening and affect a patient's quality of life[2-4]. Therefore, early breast cancer diagnosis is critical.

Molybdenum target X-ray examinations are often used to diagnose breast cancer as they have high repeatability and resolution and are noninvasive. However, they have poor penetrability, making satisfactory diagnostic results for deep and high breast cancers difficult[5,6]. Radiological technology is constantly developing, and magnetic resonance imaging (MRI) is also valuable for diagnosing breast cancer; it has high soft-tissue resolution and plainly presents abnormal enhancements in breast images, providing an objective reference for diagnosing and evaluating breast cancer[7].

Therefore, we explored the combined diagnostic efficacy of molybdenum target X-ray and MRI examinations to improve the early detection of breast cancer.

MATERIALS AND METHODS

Patient selection

This study was approved by the Ethics Committee of our hospital. All participating patients and their families provided informed consent. Patients diagnosed with breast cancer at our hospital from March 2019 to April 2021 were recruited, as were the same number of patients diagnosed with benign breast tumors during the same period.

The inclusion criteria were: (1) Pathologically confirmed cancerous or benign tumors;(2) < 80 years of age; (3) The patient had good compliance and communication skills and could cooperate to complete the investigation; (4) An estimated survival time of the breast cancer patients of > 6 mo; and (5) A disease stage of II-IV.

The exclusion criteria were patients with: (1) Other benign or malignant tumors; (2) Cardiovascular or cerebrovascular diseases; (3) Speech communication or hearing disorders; (4) Mental disorders; (5) Allergies; and (6) Contraindications to molybdenum target X-ray or MRI examinations.

All patients in both groups received molybdenum target X-ray and MRI examinations.

Molybdenum target X-ray examination

A GE Senographe 2000D Digital Mammography System (GE Healthcare, Chicago, IL, USA) with a molybdenum target X-ray camera and automatic exposure was used. Patients were instructed to stand with their arms up to optimally expose the breast to the X-ray camera. Next, horizontal and axial position breast radiography were performed for a closer examination of specific parameters, such as the breast lesion border, shape, number, and size, to determine if the axillary lymph nodes were enlarged, if there were abnormal blood vessels or microcalcification, and if the tumor lesions had invaded the skin, areola, or nipple.

MRI examination

A Magnetom Avanto 3.0T superconducting MRI scanner (Siemens, Munich, Germany) equipped with a special phased-array surface coil for the breast was used. First, the examination procedure was explained to the patient in detail. Then, patients were instructed to take the prone position, placing both breasts into the coil hole on the surface of the special phased array, then resume regular light breathing to minimize image artifacts and decreased image quality caused by chest breathing movements. The axillary position of the breast was placed into the coil as far as possible, and an auxiliary fixation device was used to pressurize the breast. A plain MRI was performed first. The sagittal and horizontal axial positions of the left and right mammary glands were obtained using the T1-weighted image (T1WI) spin-echo sequence, an echo time (TE) of 15 ms, and a repetition time (TR) of 580 ms. A short-time reversal recovery sequence was added to the T2WI turbo spin-echo sequence. The interval was 0.6 mm with a 3-mm-thick layer, and the inversion time (*i.e.*, Ti) was 230 ms, TE was 56 ms, and TR was 4820 ms. Next, dynamic enhanced MRI scanning was performed using T1WI axial scanning with fat suppression and rapid small-angle excitation of the three-dimensional dynamic imaging sequence, repeated six times. The parameters were: 55 s single scan, a 296 × 384 matrix, 104 Layers, 0.9-mm layer thickness, 1.7 ms TE, and 4.6 ms TR. A special double-tube high-pressure syringe was used to inject 0.15 mmol/kg gadolinium-dextran solution at a rate of 2 mL/s through the cubital vein.

The images were transferred to MRI workstation software for reconstruction. The maximum signal projections of the images were analyzed before and after enhancement. The area of interest in the lesions was manually selected to ensure that the MRI on the same plane was within the range of the lesions. To prevent errors, a minimum area of 2 mm^2 was used to avoid necrosis or cystic components in the lesions. Two physicians with considerable diagnostic experience examined the radiographs together, and the MRI and molybdenum target X-ray examinations were analyzed with emphasis on the number, location, shape, and size of the lesions.

Observation indexes

The examination conditions, diagnostic efficacy parameters (*e.g.*, the sensitivity, specificity, and accuracy), and examination parameters (*e.g.*, T-wave peak, peak and early enhancement rates, and apparent diffusion coefficient) were compared between the breast cancer and benign tumor groups based on the diagnosis methodology [single-method (X-ray or MRI) or combined-method (both X-ray and MRI)].

Statistical analyses

Data were analyzed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Measurement data were analyzed by *t*-test and represented by means ± SD. Enumerated data were analyzed by the χ^2 test and represented as *n* (%). Statistical significance was set at $P < 0.05$.

RESULTS

Patient demographics

In our hospital, 63 patients were diagnosed with breast cancer from March 2019 to April 2021 and were included in the study, along with 63 patients diagnosed with benign breast tumors during the same period. The mean age of the breast cancer group was 58.32 ± 10.77 years (range, 44-73 years). There was 1 mucinous carcinoma case, 2 intraductal carcinoma cases, and 60 invasive ductal carcinoma cases. Regarding the disease stage, 24 cases were stage II, 21 were stage III, and 18 were stage IV. There were 39 cases with lymph node metastasis and 24 with no metastasis. A total of 31 cases were highly differentiated, 15 were moderately differentiated, and 17 were poorly differentiated.

The mean age of the benign tumor group was 60.03 ± 11.38 years (range, 42–76 years). There were 43 fibroadenoma cases, 13 intraductal papilloma cases, and 7 Lobular tumor cases.

The baseline data, such as age, did not differ between the two groups ($P > 0.05$).

Molybdenum target X-ray and MRI examination conditions

MRI detected 53 breast cancer cases and 61 benign breast tumor cases. Molybdenum target X-ray detected 50 breast cancer cases and 60 benign breast tumor cases. The combined methodology detected 61 breast cancer cases and 61 benign breast tumor cases (Table 1).

Diagnostic efficacy

The sensitivity (96.83%) and accuracy (96.83%) of the combined methodology were higher than the single-method molybdenum target X-ray (79.37% and 87.30%, respectively) and MRI (84.13% and 90.48%, respectively) ($P < 0.05$). However, the combined methodology specificity (96.83%) did not differ from single-method molybdenum target X-ray (95.24%) or MRI (96.83%) ($P > 0.05$) (Table 2).

MRI-related examination parameters

The T-wave peak and apparent diffusion coefficient were lower in the breast cancer group (169.43 ± 32.05 and 1.01 ± 0.23, respectively) than in the benign tumor group (228.86 ± 46.51 and 1.41 ± 0.35, respectively). However, the peak early enhancement rates (1.08 ± 0.24 and 1.07 ± 0.26, respectively) were significantly higher in the breast cancer group than in the benign tumor group (0.83 ± 0. 19 and 0.75 ± 0.19, respectively; $P < 0.05$) (Table 3).

DISCUSSION

Breast cancer has a relatively high morbidity rate among females due to lacking specific clinical manifestations in the early stages, resulting in very high missed- and misdiagnosis rates. There is also adhesion between the lesion and surrounding tissue, and a lack of good activity, easily leading to negative palpation[8]. Therefore, identifying more exact breast cancer diagnosis methods remains a key topic.

Molybdenum target X-ray is a common low-cost, simple to operate diagnostic measure that can effectively identify the breast lesion's edge morphology and clarify the breast tissue density. However, the breast volume of Asian females is smaller with higher density than other populations, making a cancer diagnosis easy to miss due to the lack of good wrapping in the molybdenum target X-ray photography process. Moreover, X-ray examination emits a certain amount of radiation, leading to clinical application limitations[9,10]. It is also difficult to distinguish tumor infiltration and the margin of fibrous tissue proliferation by molybdenum target X-ray, thus disturbing the testing and evaluation conditions of breast lesions. Further, molybdenum target X-ray examination usually adopts an axial or head-to-tail projection, but the maximum diameter of breast lesions may be in an oblique position, which can affect the detection of the tumor's maximum diameter, consequently underestimating the size[11].

There are also many heterogeneous and tanglesome new blood vessels in breast cancer tissue, consisting of an incomplete fissure vascular network without relaxation and contraction, making it easy to unusually enhance the microvascular permeability, tissue gap volume, microcirculation flow, and velocity on a molybdenum target X-ray image. The incidence and progression of breast cancer are closely related to an incomplete vascular network[12]. Through intravenous injections of contrast dye with

Table 1 Molybdenum target X-ray and magnetic resonance imaging combined methodology examination conditions

X-ray	Pathological result		Total	MRI	Pathological result		Total	Both	Pathological result		Total
	+	-			+	-			+	-	
+	50	3	53	+	53	2	55	+	61	2	63
-	13	60	73	-	10	61	71	-	2	61	63
Total	63	63	126	/	63	63	126	/	63	63	126

MRI: Magnetic resonance imaging.

Table 2 Molybdenum target X-ray and magnetic resonance imaging diagnostic efficacies

Diagnostic method	Sensitivity	Specificity	Accuracy
Molybdenum target X-ray	79.37% (50/63)	95.24% (60/63)	87.30% (110/126)
MRI	84.13% (53/63)	96.83% (61/63)	90.48% (114/126)
Combined methodology	96.83% (61/63)	96.83% (61/63)	96.83% (122/126)
χ^2/P value (Combined *vs* molybdenum target X-ray)	7.568/0.006	0.000/1.000	6.572/0.010
χ^2/P value (Combined *vs* MRI)	4.513/0.034	0.262/0.609	4.271/0.039

MRI: Magnetic resonance imaging.

Table 3 Magnetic resonance imaging-related examination parameters (mean ± SD)

Group	T-wave peak	Apparent diffusion coefficient	Peak enhancement rate	Early enhancement rate
Breast cancer (n = 63)	169.43 ± 32.05	1.01 ± 0.23	1.08 ± 0.24	1.07 ± 0.26
Benign tumor (n = 63)	228.86 ± 46.51	1.41 ± 0.35	0.83 ± 0.19	0.75 ± 0.19
t value	8.351	7.581	6.482	7.887
P value	0.000	0.000	0.000	0.000

MRI: Magnetic resonance imaging.

a high-pressure syringe, MRI examination can effectively identify breast cancer lesions. Thus, it is possible to analyze and evaluate the hemodynamic characteristics of breast lesions to provide an objective reference for diagnosing and evaluating breast cancer based on the blood vessels distribution in the lesions[13]. However, there are still some limitations to diagnosing only by MRI; it has low sensitivity to common micro-needle calcifications in the early stages of breast cancer and the image quality is easily affected by several factors, such as respiratory artifacts and heartbeats[14].

Our study diagnosed breast cancer using molybdenum target X-ray and MRI examinations together and found that both T-wave peak and apparent diffusion coefficient were lower in the breast cancer group than in the benign tumor group, yet the peak and early enhancement rates were significantly higher in the breast cancer group than in the benign tumor group. The combined methodology sensitivity and accuracy were also significantly higher than either single method. These results suggest that each method has particular strengths but using both methods together enhance the diagnostic sensitivity and accuracy and reduce the risk of missed diagnosis and misdiagnosis. Several reasons may explain our results. First, molybdenum target mammography of the breast includes full-screen digital mammography and digital tomography synthetic mammography, which has been further developed in recent years and is highly sensitive to calcification, which is important for the screening and early diagnosis of breast cancer. However, in patients with dense breast cancer, the lesions are easy to cover, and the penetrating power of the molybdenum target X-ray is limited. Therefore, tiny lesions in deep glands are easily overlooked, resulting in missed diagnoses. However, an advantage to

molybdenum target X-ray examination is the ability to accurately examine microcalcifications[15].

Second, MRI accurately identifies soft tissue and then presents the tumor lesions in a multi-image and multi-directional manner. Further, it does not induce radiation damage to the body, guaranteeing patient safety. MRI can also improve the accuracy of detecting breast cancer lesions, judge dense breast tumors, perform differential diagnosis between fibrous scar and local recurrence after surgery, examine multicenter and concealing venereal lesions, and dynamically examine the blood supply around the lesion. Kuhl[16] reported that MRI examinations helped detect bilateral breast lesions by achieving three-dimensional localization of the breast and tumor, accurately measuring the distance between the breast tumor and the areola, and identifying the invasion of breast lesions to tissue. However, some reports found a significantly higher multifocal and axillary lymph node metastasis and peripheral invasion detection rate by MRI, compared to molybdenum target X-ray, but the detection rate of extensive microcalcification lesions was lower by MRI than by molybdenum target X-ray. Therefore, the advantages and disadvantages of the combined methodology are complementary and improve the overall sensitivity and accuracy[17]. However, the results of this study are limited by the nature of this being a single center study, and must be further clarified by a multi-center alliance.

CONCLUSION

Combined molybdenum target X-ray and MRI examinations improved the sensitivity and accuracy of breast cancer diagnoses, minimizing the missed- and misdiagnoses risks and promoting timely treatment intervention.

ARTICLE HIGHLIGHTS

Research background

The incidence of breast cancer among young people has been on the rise in recent years.

Research motivation

Early breast cancer diagnosis is critical.

Research objectives

Explore more sensitive and accurate breast cancer screening methods.

Research methods

Patients diagnosed with breast cancer at our hospital were recruited, as were the same number of patients diagnosed with benign breast tumors during the same period.

Research results

The combined methodology detected 61 breast cancer cases and 61 benign breast tumor cases. The sensitivity (96.83%) and accuracy (96.83%) of the combined methodology were higher than single-method magnetic resonance imaging (MRI) (84.13% and 90.48%, respectively) and molybdenum target X-ray (79.37% and 87.30%, respectively).

Research conclusions

Combined molybdenum target X-ray and MRI examinations for diagnosing breast cancer improved the diagnostic sensitivity and accuracy.

Research perspectives

Early diagnosis of cancer is very important, we need to find more early cancer diagnosis methods in the future.

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