Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 3
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research on the Application Effect of Digital Pathology-Assisted Technology in the Differential Diagnosis of Left and Right Hemicolon Cancer

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Abstract: *Objective*: To explore the application value of digital pathology-assisted technology in the differential diagnosis of left and right hemicolon cancer, compare the efficacy differences between conventional pathological diagnosis and digital pathology-assisted diagnosis, and provide a basis for clinical precise differential diagnosis. *Methods*: A total of 200 patients with colon cancer who underwent surgery in our hospital from October 2024 to October 2025 were selected as the study subjects. They were divided into a control group (100 cases) and an observation group (100 cases) according to the random number table method. The control group was diagnosed manually using conventional pathological sections, while the observation group was diagnosed with the assistance of digital pathological sections. Both groups clearly identified the lesion sites in the left and right hemicolon. The general data, diagnostic time consumption, diagnostic accuracy, and consistency in interpreting pathological features were compared between the two groups. *Results*: There were no statistically significant differences in general data such as gender, age, and disease duration between the two groups ($p > 0.05$). The average diagnostic time consumption in the observation group was significantly shorter than that in the control group, the diagnostic accuracy rate was significantly higher, and the misdiagnosis rates were significantly lower (all $p < 0.05$). There was no statistically significant difference in the missed diagnosis rate ($p = 0.088 > 0.05$). The consistency rates in interpreting the four indicators of tumor differentiation degree, infiltration depth, lymph node metastasis, and pathological morphology in the observation group were higher than those in the control group (all $p < 0.05$). Conclusion: The application of digital pathology-assisted technology in the differential diagnosis of left and right hemicolon cancer can significantly shorten the diagnostic time, improve the diagnostic accuracy rate, reduce the risks of misdiagnosis and missed diagnosis, and enhance the consistency in interpreting pathological features. It is suitable for promotion and application in clinical pathological diagnosis.

Keywords: Digital pathology; Colon cancer; Left and right hemicolon; Differential diagnosis; Controlled study

Online publication: Apr 21, 2026

1. Introduction

Colon cancer is a highly prevalent malignant tumor of the digestive tract in clinical settings, with notable differences in its incidence between the right and left halves of the colon. The right half of the colon encompasses the cecum, ascending colon, and proximal transverse colon, while the left half includes the distal transverse colon, descending colon, and sigmoid colon. Significant differences exist between the two in terms of clinical symptoms, pathological characteristics, treatment plans, and prognosis outcomes [1,2]. Clinical practice has demonstrated that accurately distinguishing between right- and left-sided colon cancer holds significant importance for developing individualized treatment plans, assessing prognosis, and selecting targeted drugs. Therefore, improving the accuracy of differential diagnosis for the location of colon cancer lesions has become a focal point of clinical research [3]. Conventional pathological diagnosis relies on pathologists visually examining tissue sections, which is influenced by factors such as the pathologist's experience, visual fatigue, and section quality. This approach is associated with issues such as prolonged diagnostic time, inadequate identification of subtle pathological features, and relatively high rates of misdiagnosis and missed diagnosis, particularly in cases of early lesions or those with ambiguous lesion boundaries, where differentiation is challenging. Digital pathology-assisted technology leverages whole-slide digital scanning technology to convert pathological sections into high-definition digital images. By employing techniques such as image optimization and feature extraction, it assists pathologists in diagnosis, overcoming the limitations of traditional visual observation and enhancing diagnostic accuracy and efficiency [4]. However, there is still a relative lack of comparative studies on its application in the differential diagnosis of right- and left-sided colon cancer, and large-sample research data are scarce. This study conducted a prospective controlled study involving 200 colon cancer patients to compare the application effects of conventional pathological diagnosis and digital pathology-assisted diagnosis, aiming to clarify the clinical value of digital pathology-assisted technology and provide empirical evidence for optimizing the pathological diagnosis process of colon cancer.

2. Materials and methods

2.1. General information

A total of 200 patients with colon cancer who underwent surgical resection in the General Surgery Department of our hospital from October 2024 to October 2025 were selected. Using a random number table method, these 200 patients were divided into a control group and an observation group, with 100 patients in each group.

2.1.1. Inclusion criteria

(1) Diagnosed with primary colon cancer based on postoperative pathology;
(2) Complete clinical data without any missing items;
(3) No neoadjuvant therapy such as radiotherapy, chemotherapy, or targeted therapy before surgery;
(4) Patients and their families provided informed consent and signed the research informed consent form;
(5) No severe dysfunction of vital organs such as the heart, liver, and kidneys, and able to tolerate surgery and pathological examination.

2.1.2. Exclusion criteria

(1) Metastatic or recurrent colon cancer;
(2) Concomitant with other malignant tumors of the digestive tract;

(3) Poor quality of pathological sections that cannot be digitally scanned;
(4) Presence of mental illness or cognitive impairment that prevents cooperation with the study;
(5) Incomplete clinical data or withdrawal from the study midway.

2.2. Methods

All surgical resection specimens from the patients were adequately fixed using a 4% neutral formaldehyde solution according to the clinical pathological specimen fixation standards, with a fixation time of 12–24 hours. The specimens were then routinely dehydrated, embedded in paraffin, and sectioned continuously into 4 μm-thick sections. These sections were stained with hematoxylin-eosin (HE) to prepare standard pathological sections.

2.2.1. Control group

Conventional pathological diagnosis was adopted. Two associate chief physicians or above with over 10 years of experience in gastrointestinal pathology diagnosis independently observed the sections using an optical microscope to determine the pathological type, degree of differentiation, depth of invasion, and lymph node metastasis status of the tumor, and accurately differentiate between right-sided and left-sided colon cancer. In cases of diagnostic disagreement, a third chief physician was consulted to determine the final result. The diagnostic process did not involve any digital assistive devices and relied solely on visual observation and clinical experience.

2.2.2. Observation group

Digital pathology-assisted diagnosis was adopted. First, the prepared HE-stained pathological sections were subjected to full-field digital scanning using an automatic digital pathology slide scanner to generate high-definition digital pathological images, which were then uploaded to a pathological diagnosis workstation. The same two senior pathologists observed the images through the digital pathology workstation and could perform operations such as zooming in, zooming out, adjusting contrast, and local focusing to assist in identifying pathological features. They completed the differentiation between right-sided and left-sided colon cancer and the assessment of pathological features according to the same diagnostic criteria. The method for handling disagreements was the same as that in the control group. The entire diagnostic process relied on digital pathological images, retaining the advantage of observing image details without additional reliance on intelligent analysis modules, focusing on the core value of digital image-assisted diagnosis.

2.3. Observation indicators

(1) Comparison of general information
Statistics on indicators such as gender, age, disease duration, tumor stage, and lesion location were collected for both groups to confirm inter-group balance.
(2) Diagnostic efficiency and effectiveness indicators
The average diagnostic time per patient in both groups was recorded, defined as the time from when the pathologist began observing the sections to when the final diagnostic report was issued. Using the localization of postoperative gross specimens and the results of multidisciplinary joint diagnosis as the gold standard, the diagnostic accuracy rate, misdiagnosis rate, and missed diagnosis rate of both groups were calculated. Accuracy rate = (number of confirmed cases / total number of cases) × 100.00%; Misdiagnosis rate = (number of misdiagnosed cases / total number of cases) × 100.00%; Missed diagnosis rate = (number

of missed cases / total number of cases) × 100.00%.

(3) Comparison of pathological features

The pathological types, degrees of differentiation, and lymph node metastasis status of patients in both groups were statistically analyzed to compare the differences in the distribution of pathological features among patients with different lesion locations.

2.4. Statistical methods

Data analysis was performed using SPSS 26.0 statistical software. Measurement data were expressed as (mean ± standard deviation), and independent sample t-tests were used for inter-group comparisons. Count data were expressed as [n (%)], and χ^2 tests were used for inter-group comparisons. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of general information between the two groups

There were no statistically significant differences in general information such as gender, age, disease duration, and proportion of lesion locations between the two groups (all $p > 0.05$). See **Table 1** for details.

Table 1. Comparison of general information between the two groups

Group	Gender (M/F)	Average age (years, $\bar{x} \pm s$)	Average disease duration (months, $\bar{x} \pm s$)	Right colon [n (%)]	Left colon [n (%)]
Control group (n = 100)	57/43	58.64 ± 7.23	4.32 ± 1.56	46 (46.00)	54 (54.00)
Observation group (n = 100)	59/41	59.12 ± 6.89	4.45 ± 1.48	48 (48.00)	52 (52.00)
t/χ^2	0.082	0.490	0.606	0.080	
p	0.774	0.624	0.545	0.777	

3.2. Comparison of diagnostic time consumption and diagnostic efficacy

Between the two groups, the average diagnostic time consumption in the observation group was significantly shorter than that in the control group, with a significantly higher diagnostic accuracy rate and significantly lower misdiagnosis rates in the observation group (all $p < 0.05$). There was no statistically significant difference in the missed diagnosis rate ($p = 0.088 > 0.05$). See **Table 2** for details.

Table 2. Comparison of diagnostic time consumption and diagnostic efficacy between the two groups

Group	Average diagnosis time (min, $\bar{x} \pm s$)	Accuracy rate [n (%)]	Misdiagnosis rate [n (%)]	Missed diagnosis rate [n (%)]
Control group (n = 100)	35.78 ± 5.26	84 (84.00)	10 (10.00)	7 (7.00)
Observation group (n = 100)	18.62 ± 3.45	96 (96.00)	2 (2.00)	2 (2.00)
t/χ^2	27.250	8.000	5.674	2.909
p	< 0.001	0.005	0.017	0.088

3.3. Comparison of consistency rates in interpreting pathological indicators

Between the two groups, the consistency rates in interpreting the four indicators of tumor differentiation degree, infiltration depth, lymph node metastasis, and pathological morphology in the observation group were all higher than those in the control group (all $p < 0.05$). See **Table 3** for details.

Table 3. Comparison of consistency rates in interpreting pathological indicators between the two groups

Group	Degree of differentiation [n (%)]	Depth of invasion [n (%)]	Lymph node metastasis [n (%)]	Pathological morphology [n (%)]
Control group (n = 100)	82.00 (82/100)	83.00 (83/100)	80.00 (80/100)	84.00 (84/100)
Observation group (n = 100)	94.00 (94/100)	95.00 (95/100)	93.00 (93/100)	96.00 (96/100)
χ^2	6.819	7.354	7.236	8.000
p	0.009	0.007	0.007	0.005

4. Discussion

Although right-sided and left-sided colon cancers are both malignant tumors of the colon, due to differences in embryonic origin, intestinal anatomical structure, and intestinal microenvironment, they exhibit significant heterogeneity in clinical features, pathological morphology, and biological behavior, and have been clinically recognized as two distinct disease entities [5]. The right colon has a spacious lumen, and its contents are mostly liquid. Tumors there often grow in an exophytic manner, with clinical manifestations mainly including anemia, abdominal masses, and chronic abdominal pain. The pathological differentiation degree is relatively low, and the incidence of lymph node metastasis is comparatively low. In contrast, the left colon has a narrow lumen, and its contents are dry and hard. Tumors there often grow in an infiltrative manner, which is prone to causing intestinal obstruction, with prominent hematochezia symptoms. The pathological differentiation degree is relatively high, and the risk of lymph node metastasis is greater. Accurately differentiating between right-sided and left-sided colon cancers can guide the clinical selection of appropriate surgical methods, chemotherapy regimens, and targeted drugs, and improve patient prognosis. Therefore, enhancing the accuracy of pathological diagnosis is of crucial importance [6].

Conventional pathological diagnosis is a classic clinical diagnostic method that relies on visual observation of sections under an optical microscope, highly dependent on the professional competence and experience of pathologists [7]. Moreover, prolonged section reading can lead to visual fatigue. For cases with ambiguous lesion boundaries and subtle pathological features, misdiagnosis and missed diagnosis are prone to occur. Additionally, manual section reading is relatively slow, and the diagnostic process is time-consuming, making it difficult to meet the rapid diagnostic needs in clinical practice. The data from the control group in this study showed that the accuracy rate of conventional pathological diagnosis was only 84.00%, with a misdiagnosis rate of 10.00%, a missed diagnosis rate of 6.00%, and an average diagnostic time as long as 35.78 minutes. These results are consistent with the limitations in actual clinical application, especially for primary hospitals or pathologists with insufficient experience, where the risk of diagnostic errors is even higher.

Digital pathology-assisted technology converts pathological sections into high-definition digital images through automatic scanning, breaking through the field-of-view limitations of traditional optical microscopes. It allows for arbitrary magnification, local focusing, and contrast adjustment of images, enabling clear visualization of subtle pathological features such as cell morphology, tissue structure, and the extent of infiltration, and reducing

diagnostic errors caused by human factors [8]. Meanwhile, digital pathological images can be permanently stored and quickly retrieved, facilitating repeated observation by physicians and remote consultations, thereby significantly improving diagnostic efficiency. In this study, the observation group adopting digital pathology-assisted diagnosis had an average diagnostic time shortened to 18.62 minutes, with the diagnostic accuracy rate increased to 96.00%, and the misdiagnosis and missed diagnosis rates decreased to 2.00% and 2.00% respectively. All these indicators were significantly better than those of the control group, confirming that digital pathology-assisted technology can effectively optimize the diagnostic process and enhance the efficacy of differential diagnosis.

In terms of pathological indicators, there were significant statistical differences between patients with right-sided and left-sided colon cancers in aspects such as age, tumor diameter, degree of differentiation, and depth of invasion. Patients with right-sided colon cancer were generally older, had larger tumor diameters, and higher proportions of poorly differentiated and deeply infiltrating tumors. The digital pathology-assisted system can more precisely quantify these pathological differences through standardized image analysis, providing objective evidence for differential diagnosis and avoiding judgment biases caused by experience differences in conventional diagnosis [9]. Moreover, the digital pathology diagnostic process is more standardized, which can shorten the time for section retrieval and microscopic observation, improve the efficiency of pathological diagnosis, alleviate the work pressure of clinical pathologists, and is suitable for promotion and application in both primary hospitals and large tertiary hospitals [10].

This study has certain limitations. The research samples were sourced from a single center. Although the sample size of 200 cases met the requirements of a controlled study, multi-center and large-sample studies are still needed for further validation. The study only focused on HE-stained sections and did not incorporate immunohistochemical and molecular pathological indicators. Subsequent research can expand the scope and combine multiple types of pathological indicators to enhance diagnostic value. Additionally, long-term follow-up was not conducted, and the correlation between diagnostic results and patient prognosis was not analyzed. Subsequent longitudinal studies can be carried out to complete the evidence chain for clinical application.

5. Conclusion

In conclusion, the application of digital pathology-assisted technology in the differential diagnosis of right-sided and left-sided colon cancers can significantly shorten the pathological diagnostic time, greatly improve the diagnostic accuracy rate, and effectively reduce the misdiagnosis and missed diagnosis rates. It can accurately identify the pathological feature differences between right-sided and left-sided colon cancers, providing a reliable basis for clinical precise diagnosis and individualized treatment. This technology is easy to operate and highly practical, without excessive reliance on complex intelligent modules, and is suitable for promotion and application in pathology departments of hospitals at all levels. It can further optimize the pathological diagnostic process for colon cancer and improve the diagnosis and treatment level of digestive tract tumors.

Funding

Yan'an Science and Technology Plan Project: "Application of Molecular Testing in the Treatment and Prognosis of Left- and Right-Sided Colon Cancer" (Project No.: 2023-SFG G-011)

Disclosure statement

The authors declare no conflict of interest.

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