CASE REPORT

Intrauterine Device Migrated into the Urachus: A Case Report

Jian Chen, PhD; Jianlin Lu, PhD; Tuanjie Che, PhD; Weiguo Wang, PhD

ABSTRACT

Background • The intrauterine device is the most commonly used female contraceptive device, but the related complications of intrauterine devices are also common. Sometimes, intrauterine devices can cause uterine perforation, migrating into the abdominal cavity or other organs. At the same time, the intrauterine device may break into several small segments, migrate to distant organs, and even cause misdiagnosis.

Objective • This study assessed the role of laparoscopy in treating intrauterine device migration.

Design • This was a retrospective study involving in a review of a single case.

Setting • This study was conducted at Suzhou Hospital, Affiliated Hospital of Medical School, Nanjing University.

Participants • This study focued on a single case acout a 64-year-old female patient presented with repeated painless gross hematuria. She had a history of placing an intrauterine device and "removed the intrauterine device" in a local hospital for 20 years.

Interventions • Laparoscopic ureterectomy was chosen based on the specific findings from the computerized tomography scan and cystoscopy. Abdominal computerized tomography showed high-density foreign body under the abdominal wall, size 2.29×0.51 cm, showed signs of edema in the surrounding tissue, and it was connected to the bladder wall. High-density lesions in the urachus and urachus calculi were considered. Cystoscopy showed the bubble position on the top of the bladder was depressed, a dark foreign body seemed to be seen inside, and the local mucosa was congested. The urachus foreign body, the urachus stone, was considered.

Results • Computerized tomography examination showed a high-density space-occupying lesion at the position of the bladder and urachus tube. Cystoscopy showed local congestion at the top of the bladder, like urachus and dark foreign bodies, and no obvious abnormality in other parts of the bladder. Laparoscopy showed the urachus position was congested and edema, with local adhesion of the greater omentum and foreign bodies. The foreign bodies and surrounding tissues were removed by laparoscopic ureterectomy. Pathology showed tubular tissue, metal and plastic foreign bodies, fibrous tissue proliferation, and chronic inflammatory cell infiltration around the foreign bodies.

Conclusion • The intrauterine device is a common contraceptive tool, and intrauterine device rupture and migration are normal. Migration to rare locations can lead to misdiagnosis. It can be removed by endoscopy, and combined with imaging and pathological examination, a correct diagnosis can finally be obtained. The patients should be advised to undergo regular check-ups after the procedure. These cases may provide diagnostic reference for similar symptoms of intrauterine device migration. (*Altern Ther Health Med.* [E-pub ahead of print.])

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BACKGROUND

The intrauterine device (IUD) is an effective birth control tool that is placed inside the uterine cavity with high relative safety and the average use rate of the world is 14.3%, which is one of the most widely used contraceptive methods.[1,2] IUD is usually made of stainless steel, plastic, silicone rubber, and other materials; without medicine, an IUD is called an inert intrauterine device, such as an IUD plus progesterone or copper, which can improve the contraceptive effect, called with medicine or active IUD, is one of the commonly used birth control devices in China.[3] There are many kinds of intrauterine devices commonly used in China: metal single ring, twist ring, mixed ring, IUD ring, T-ring, and so on.[4] The contraceptive principle of the IUD is: when there is an embryo to be implanted in the uterus, the continuous action of the IUD scratches the uterine wall, causing aseptic inflammation of the uterus, so that the embryo cannot be implanted in the uterus normally to conceive, resulting in abortion, in order to achieve the purpose of contraception.[5] However, because the absolute population of the IUD is large, its complications are common

Figure 1-2. CT scan and reconstruction showing high-density foreign body in the abdominal wall

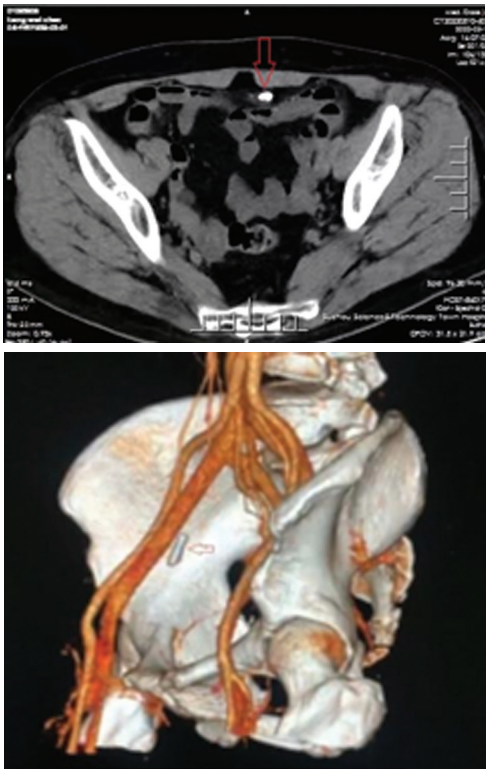
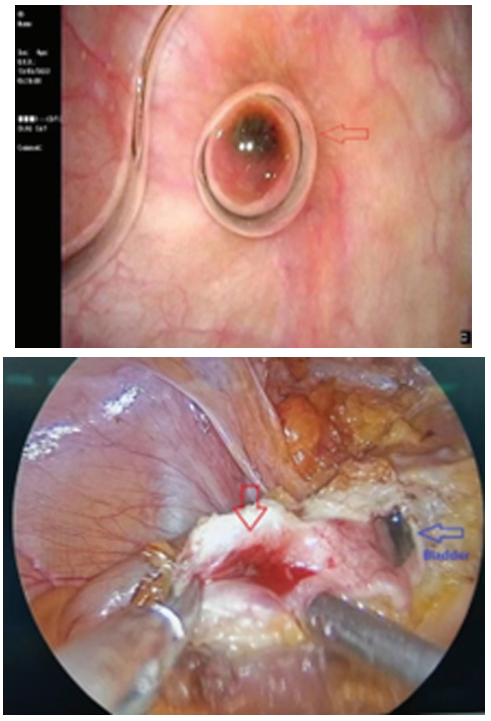


Figure 3-4. Endoscopic view of the top of the bladder tissue congestion and edema, with foreign bodies in the tissue



in clinical practice. Its complications include hemorrhage, uterine perforation, infection, ectopic migration, rupture, deformation, dislocation, and downward movement.[6] Among them, migrated IUD is a serious complication, with an incidence of 1.3 to 1.6%,[7] and the migration of IUD is more common in the abdominal cavity and bladder.[8-11] The urachus is generally atrophied and closed before birth. The urachus belongs to the extraperitoneal structure, which is the midline structure from the top wall of the bladder, the front wall and the umbilical cord. It is generally about 3-4 cm long and 1cm in diameter.[12] Most of the urachus will gradually degenerate after birth, forming a median umbilical ligament. The patent urachus means that the urachus is not completely closed, and there is a tube between the navel and the bladder, through which urine can flow out of the bladder and out of the navel.[13] If the urachus is not closed in adults, it may lead to internal liquid, such as urine and sac fluid, and bacterial infection is easy to occur for a long time, causing inflammation, ulcers, etc., and infected secretions are not easy to discharge, which may be expelled from the umbilical cord or bladder. At this time, it may lead to umbilical infection, and red, swollen, heat, pain and other phenomena around the umbilical cord appear. There may be frequent urination, urgent urination, urine pain and other phenomena.[14] Patent urachus is a rare deformity, and the patent urachus can be combined with foreign bodies such as stones. IUD migration means that due to improper operation, uterine perforation, or the IUD is too large and hard, the uterine wall is thin and soft, and the uterine contraction causes the IUD to gradually move outside the uterine cavity.[15] The misdiagnosing an IUD migration as a urachal stone may delay the correct treatment. Therefore, accurate diagnostic techniques are of great importance in unusual presentations of IUD. Many studies have reported the cases of IUD migration,[16] but IUD migration to the urachus is rare. We now encounter a case of migrated IUD misdiagnosed as a stone. The report was as follows:

CASE REPORT

The patient, a 64-year-old female, was admitted to the hospital with "recurrent painless gross hematuria for 1 month." The patient had repeated gross hematuria in the past 1 month, no obvious dysuria, and no fever. She had a medical history of placing an intrauterine device. She "removed" the IUD at a local health center 20 years ago. The removal process was unknown, and there was no history of other operations and trauma.

Abdominal computerized tomography (CT): high-density foreign body under the abdominal wall, long shape, size 2.29×0.51 cm, showed signs of edema in the surrounding tissue, and it was connected to the bladder wall. High-density lesions in the urachus and urachus calculi were considered (Figure 1-2).

Cystoscopy: The bubble position on the top of the bladder was depressed, a dark foreign body seemed to be seen inside, and the local mucosa was congested. The urachus foreign body, the urachus stone, was considered (Figure 3).

Laparoscopic ureterectomy was performed. During the operation, local tissue edema at the top of the bladder was

Figure 5-6. Local adhesions and separation of adhesions seen under laparoscopy

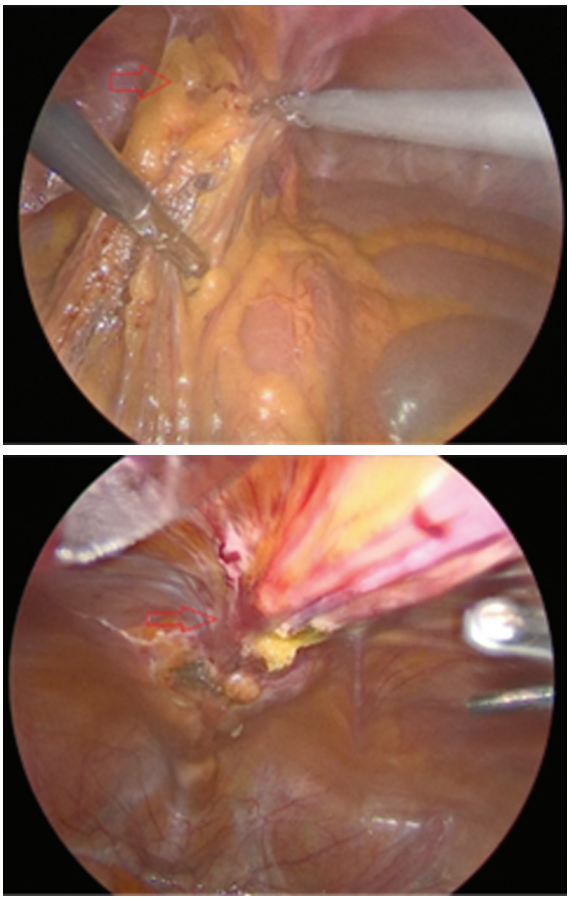
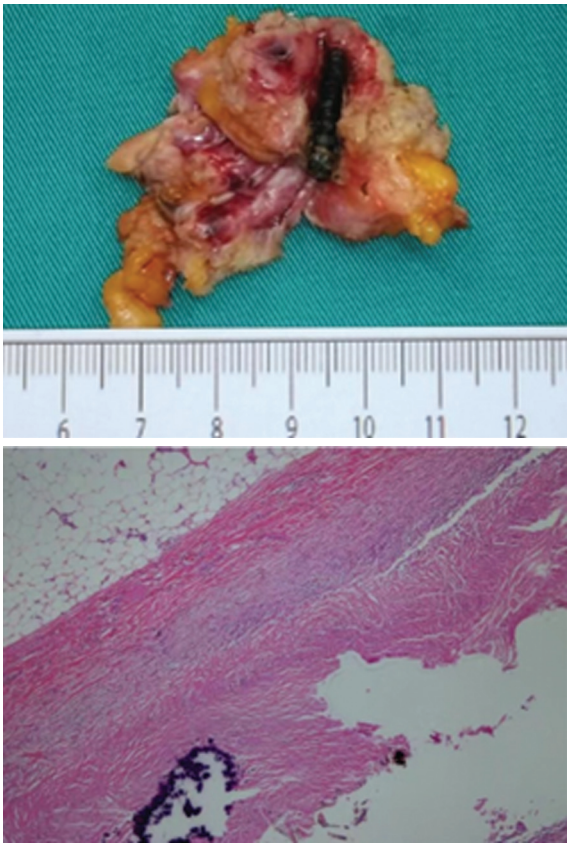


Figure 7-8. Lesion specimens and pathological pictures taken out (hematoxylin and eosin, 10×10)



observed (Figure 4), and there was adhesion of the greater omentum around it (Figure 5-6). The edema tissue and part of the bladder wall were excised together, and the bladder incision was sutured with an absorbable suture.

Postoperative pathology: 1 (urachus) tubular tissue, with long rod-shaped plastic + metal-like foreign bodies inside, fibrous tissue around the foreign body proliferated and wrapped with many chronic inflammatory cells' infiltration, the tube wall was composed of smooth muscle and adipose tissue, combined with clinical, in line with urachus (Figure 7-8).

Combined with the foreign body morphology, the final diagnosis was intrauterine device urachus migration. One week after the operation, the catheter was removed, and urination was normal, the patient was discharged from the hospital.

DISCUSSION

IUDs are widely used long-term contraceptives, with various shapes and materials, including copper and silver, and mixed with plastic and other materials, and some are coated with active substances such as progesterone.[1] Because of its wide application, its complications are common clinically, including abdominal pain, abnormal menstruation, and so on. IUD breakage and migration are also common clinically. The reasons for the IUD migration may be related to the lack of experience of the surgeon, the implantation of an IUD in the early stage of childbirth and lactation, the history of perforation, and congenital abnormal uterine morphology, such as excessive forward or backward inclination of the uterus.[17] The intrauterine device can migrate to any position in the abdominal cavity, and there may be severe complications of abdominal pain and bleeding.[8] Migration places in the urinary system are more common in adjacent organs such as the bladder, causing bladder stones, which may be found with complications such as frequent urination, urgency, and hematuria.[9-11] The incidence of IUD migration is 1.3 to 1.6%.[18] This patient complained of hematuria, but because of the particularity of the anatomy of the urachus, there was no urinary tract obstruction, dysuria, or other symptoms.

Because of the particularity of the appearance of the IUD, it is easier to diagnose with the aid of imaging equipment.[19] However, after the rupture of the IUD, the appearance of the IUD loses its specificity, which may lead to misdiagnosis. This patient had a record of "removing" the IUD, and the remaining part of the IUD was difficult to judge, thus causing misdiagnosis. In clinical practice, the IUD was mistaken for ectopic pregnancy because of a similar look in CT, and the IUD has been placed again.[9]

Clinically, IUD is found to be migrated, usually through open surgery,[9,10] laparoscopic surgery[8], cystoscopy,[19] or other

endoscopic surgery, such as laparoscopic combined. Cystoscopy combined with surgery[20] to remove and so on. In this case, a CT examination showed a high-density space-occupying lesion at the position of the bladder and urachus tube. Cystoscopy showed local congestion at the top of the bladder, like urachus and dark foreign bodies, and no obvious abnormality in other parts of the bladder. Laparoscopy showed that the urachus position was congested and edema, with local adhesion of the greater omentum and foreign bodies. The foreign bodies and surrounding tissues were removed by laparoscopic ureterectomy. Pathology showed tubular tissue, metal and plastic foreign bodies, fibrous tissue proliferation, and chronic inflammatory cell infiltration around the foreign bodies. Consistent with our findings, Ko et al. have indicated 2 cases of IUD migration to the lower urinary tract, and both cases were managed endoscopically, with excellent outcomes.[21]

Patent urachus is rare in clinical practice. As a narrow cavity with a certain distance from the uterus, IUD migrated to the urachus, which is rare in clinical practice, and no relevant literature has been found so far; however, patent urachus stones have been reported in the literature.[22] Because of the high density of the IUD, this case was initially misdiagnosed as stones. The patient was informed about the potential risks of migration and the options available if complications arise. Fortunately, the treatment principles of the two are the same. As a congenital malformation, the general treatment principle is urachus resection,[23,24], so the misdiagnosis, in this case, did not affect the treatment effect, and the treatment effect, in this case, was satisfying.

The IUD is best placed 3 to 7 days after menstruation is clean. If the ring is placed after artificial abortion, it is necessary to grasp the depth of the uterine cavity, which is less than 10 cm. Lactation release ring should be more than 3 months after delivery, and 6 months after cesarean section is appropriate. If it is a natural abortion, it should be appropriate to restore more than one normal menstrual period. Besides, regular post-insertion check-ups are important. Generally, the first check after the ring is after the first menstruation after the ring is put, the second is within 3-6 months after the ring is put, the third check is after the ring is reviewed for 12 months, and then reviewed once a year. If the amount of menstruation after the ring is significantly increased, the menstrual period is significantly prolonged or there is often a small amount of bleeding and serious lumbar acid and abdominal pain, these are abnormal phenomena, should go to the hospital for examination.

This case suggests that, in patients with a history of placing an IUD, if there is a urachus foreign body or other intra-abdominal foreign body, it should be noted that the IUD may be migrated to avoid misdiagnosis and mistreatment or medical disputes. The future research of our study was to explore the role of imaging in early detection of IUD migration. The limitation of our study was that our results was unable to generalize findings to all cases of IUD migration.

CONCLUSION

IUD rupture and migration can be diagnosed by imaging examination. Advances in imaging technology can improve the diagnosis of migrating IUDs, enable more precise positioning of IUDs, and guide the selection of the most appropriate surgical approach for removal. In special cases, such as ruptured intrauterine device urachus migration, laparoscopic surgery and pathological examination are needed for the final diagnosis. For symptomatic migrated IUDs, surgical removal is the first-line treatment. The position of the IUDs should be reviewed regularly after the intrauterine device is discharged, and the IUDs should be removed as soon as possible once diagnosed to avoid serious consequences. Patients should adhere to long-term follow-up after IUD placement. Collaboration between radiologists, gynecologists, urologists and surgeons can facilitate accurate diagnosis and appropriate treatment plans, ensuring comprehensive care for patients.

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ORIGINAL RESEARCH

Retrospective Analysis of Adverse Factors Impacting Medicine Logistics

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ABSTRACT

Background • Medicine logistics, particularly cryogenic storage, maintains pharmaceutical efficacy and safety. Ensuring seamless transportation and storage prevents spoilage, degradation, or contamination, safeguarding patient health.

Objective • This study aimed to analyze the relationships among the components of the medication cold chain logistics system using grey relational analysis (GRA). Additionally, we utilized GRA to construct an adjacency matrix, facilitating a comprehensive understanding of the interdependencies within the system.

Methods • Data from pertinent indices spanning 2021 and 2022 were utilized to conduct a quantitative analysis using GRA. This analysis aimed to identify the most influential elements affecting the growth of pharmaceutical cold chain logistics in a specific location. The negative aspects of the medication cold chain logistics system in particular areas were examined by assessing the grey relationship grades between various components and the medicine cold chain logistics system in those regions.

Results • The analysis revealed significant insights into the correlated risk factors impacting medicine logistics operations. Through an examination of the financial status and operational processes of medicine logistics assets, four categories of risks were identified, encompassing transportation, storage, distribution, and quality management. These categories were established by analyzing the most significant risk factors across these operational domains. Additionally, GRA was employed to assess the factors influencing medicine logistics. The study found a strong relationship between key parameters, such as transportation risk and site facilities and equipment, and the growth of the pharmaceutical logistics sector. Operation risk emerged as the least influential factor, while site facilities and equipment, transportation risk, and operation risk demonstrated substantial influence on the region's medical logistics sector growth.

Conclusion • This study provides important recommendations to improve medicine logistics, aiming to mitigate adverse effects and elevate inventory management. Implementation can enhance efficiency and safety in the medicine supply chain, benefiting patient care and public health. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

The supply chain (SC) encompasses various processes, including identifying consumer demands, selecting appropriate products, negotiating with suppliers, payment transactions, warehousing, distribution, and redistribution.[1] Therefore, supply chain management (SCM) involves interactions between suppliers and customers, addressing issues within and between businesses, both upstream and downstream.[2] SCM initially emerged in manufacturing but has significantly benefited the healthcare sector. Its adoption has notably influenced hospital performance by reducing waste, preventing medical errors, improving nursing care and services, and enhancing operational efficiency.[1,2]

Over the past few decades, decision-making challenges in healthcare have garnered considerable attention from scholars, particularly in systems engineering and operations research (OR). This field presents novel theoretical and practical difficulties. For instance, any discovery or advancement related to the quality of services offered can have a profound and immediate impact on both the economy and public health.[3] Moreover, the reduction of public healthcare costs has been a significant concern for national administrative departments, given its considerable impact on total public expenditure. Therefore, any initiatives aimed at cost reduction could profoundly affect the medicine logistics system overall.[2]

Healthcare SCM encompasses three distinct processes: financial, informational, and product-related.[4] On the one hand, medical logistics encompasses the provision of medications, medical supplies, surgical consumables, medical equipment, sanitary consumables, food, daily supplies, equipment, and other supplementary goods and necessities.[5] The logistics of medications play a crucial role in ensuring effective operational functions within the healthcare industry.[6]

Due to the critical role of medicine logistics in hospital operations, effective internal organization is essential. However, this task is challenging, given the complexity of pharmaceutical healthcare systems. These systems involve managing products with diverse characteristics, decentralized organizational responsibilities for logistics, various types of final customers, and the impact of logistics on the quality of nursing care provided to patients.[4-6]

Hence, there is an urgent need to identify key factors for enhancing the efficiency of drug logistics and optimizing supply chain processes in the medical setting. This study highlights the significance of strengthening strategic supply chain management by addressing adverse factors impacting drug logistics. It aims to provide theoretical support for resolving challenges in drug logistics.

MATERIALS AND METHODS

Grey Relational Analysis (GRA)

The study utilized Grey relational analysis (GRA) to determine the relative relevance of various criteria in selecting cloud manufacturing service providers. GRA, an effective and exploratory data analysis tool, allowed for objective weighting of negative aspects encountered in medication logistics and transportation. Algorithms calculated each scheme assessment index, facilitating the identification of causality.[5]

Variables and Sequences in Grey Relational Analysis (GRA)

The reference sequence, denoted as the dependent variable Y, represents a sequence that reflects the behavioral characteristics of the system. It is symbolized as follows: $x_0 = \{x_0(k) \mid k = 1, 2, 3, ..., n\}$

On the other hand, the comparative sequence, equivalent to the variable X, influences the behavioral characteristics of the system. It is symbolized as: $x_i = \{x_i(k) \mid k = 1, 2, \ldots, n|, i = 1, 2, \ldots, m$

Dimensionless Treatment of Original Data

The original data within the system may influence calculation results due to variations in units. To mitigate this effect and streamline calculation and comparison processes, the data underwent dimensionless transformation before GRA. This study employed the normalization method with the following formula:

Normalization of negative correlation indexes: $x_i^*(k) = [x_i(k) - \min_{(k)} x_i(k)] / \max_{(k)} x_i(k) - \min x_i(k)]$ $k = 1, 2, \ldots, n$; $i = 0, 1, 2, \ldots, n$

Normalization of positive correlation indexes: $x_i^*(k) = [\max_{(k)} x_i(k) - x_i(k)] / \max_{(k)} x_i(k) - \min x_i(k)]$ $k = 1, 2, \ldots, n$; $i = 0, 1, 2, \ldots, n$

Calculation of Difference Sequence

The absolute difference between the reference and comparative sequences was calculated to quantify the difference between the two sets of data. This analysis aided in identifying the extent of variation and informs subsequent comparisons and evaluations. $\Delta i(k) = | x_0^*(k) - x_i^*(k) |$, $i = 1, 2, \ldots, m$

Computation of Correlation Coefficient and Degree of Association

At time K, the grey relational coefficients for x_0^* and x_i^* were computed to assess the degree of association between the reference sequence and the comparative sequence. This analysis aided in understanding the relationship between the two sets of data and provided insights into their correlation over time. $\varepsilon_i(k) = [\min_{(i)} \min_{(k)} \Delta i(k) + \rho \max_{(i)} \max_{(k)} \Delta i(k)] / [\Delta i(k) + \rho \max_{(i)} \max_{(k)} \Delta i(k)]$

The resolution coefficient, denoted as ρ, varies depending on specific circumstances. In this paper, ρ was set to 0.5. The relational degree was calculated using the following formula, which utilizes the correlation coefficient at each instance as the centralized average: $r_i = 1/n \sum_{i=1}^{n} \varepsilon_i(k)$ $k = 1, 2, \ldots, n$; $i = 0, 1, 2, \ldots, m$

The factor increases with the grey relational degree in the derived findings, indicating a stronger association between variables in the derived results.

RESULTS

Correlated Risk Factors in Medicine Logistics Operations

Table 1 presents the correlated risk factors associated with each stage of the medicine logistics process,

Table 1. Types of Risk Factors for Medicine Logistics

Classification of Risk Factors	Key Risk Factors
Transportation	Hardware Equipment
	Software Equipment
Storage	Storage
	Temperature Control
	Self-Allocation
Delivery	Third-Party Distribution
	Loading And Unloading
	Picking And Packaging
	Self-Allocation
Quality Assurance	Supply Of Medicines
	Talent Quality
	Selection Of Suppliers
	Market Demand

Note: This table categorizes the risk factors associated with medicine logistics into four classifications: Transportation, Storage, Delivery, and Quality Assurance. Each classification includes key risk elements representing specific aspects of logistics management. For example, under Transportation, risk factors include Hardware equipment and Software equipment, while Storage encompasses factors such as Storage, Temperature control, and Self-allocation. Delivery factors involve Third-party distribution, Loading and unloading, Picking and packaging, and Self-allocation. Quality Assurance factors include Supply of medicines, Talent quality, Selection of suppliers, and Market demand. Understanding and addressing these risk factors are essential for ensuring the efficient and effective operation of medicine logistics systems.

Table 2. Grey Relational Degree Analysis of Medicine Logistics Risk Factors

Type of Risk	Risk Factor	Contents of Risk Elements	Relational Degree	Ranking
Site Facilities And Equipment (0.764)	Hardware Facilities	Refrigeration equipment	0.043	38
		Refrigeration vehicle	0.47	20
		Temperature control equipment	0.062	37
		Maintenance of machinery and facility checking	0.65	14
		Machining equipment	0.837	7
		Processing equipment	0.898	2
	Software Facilities	Inventory information system	0.786	10
		Extensive and reliable information sharing	0.398	24
		Supplier management system	0.402	23
Transport Risk (0.984)	Self-Allocation	Staff technology	0.932	1
		Route planning	0.689	12
		The effectiveness of a distribution network and its design	0.394	25
		Damage rate of goods	0.841	6
	Third-Party Distribution	Monitoring strength	0.817	9
		Third-Party Business Qualifications	0.376	27
		Distribution efficiency	0.612	16
Operation Risk (0.721)	Picking And Packaging	Picking method	0.607	17
		Packaging technology	0.404	22
		Operation standard	0.49	19
		Picking efficiency	0.751	11
		Packaging level division	0.263	32
	Lay In	Storage temperature	0.496	18
		Storage design	0.836	8
		Storage method	0.374	28
		Storage time	0.19	35
		Storage quantity	0.257	33
	Temperature Control	Staff awareness	0.214	34
		Equipment and tools cleaning	0.896	3
		Site cleaning	0.282	31
	Processing	Loading and unloading methods	0.662	13
		Location of goods	0.448	21
External Environment (0.633)	Supply of Medicines	Ordering plan	0.37	29
		Ordering period	0.347	30
		Product options and characteristics	0.618	15
	Talent Quality	Staff development and performance appraisals	0.179	36
	Selection Of Suppliers	Supply capacity	0.878	4
		Integrity of suppliers	0.392	26
	Market Demand	Market demand fluctuation	0.858	5

Note: This table presents the grey relational degree analysis of risk factors associated with medicine logistics. Risk factors are categorized into types, including Site facilities and equipment, Transport risk, Operation risk, and External environment, each with corresponding risk elements and relational degrees. The relational degree indicates the strength of the relationship between the risk factor and the growth of the pharmaceutical logistics sector, with higher values indicating a stronger impact. The ranking column shows the relative importance of each risk element within its respective category. Understanding these relational degrees is crucial for prioritizing risk management strategies and improving the efficiency and effectiveness of medicine logistics operations.

encompassing transportation, storage, distribution, and quality management. These associations were identified through an analysis of the financial status and operational processes of medicine logistics assets in the region during 2020-2021. In this analysis, we outlined four categories of risks linked to medical cold chain logistics, with specific risk elements outlined for each category in Table 2. We established this categorization by analyzing the most significant risk factors across the core operational domains of transportation, storage, distribution, and quality management.

Analysis of Factors Influencing Medicine Logistics

Calculation of Grey Relational Degree

To assess the growth of the regional pharmaceutical logistics business, four primary indices were utilized: (1) site facilities and equipment, (2) transportation risk, (3) operation risk, and (4) external environment. In this study, these four indices were chosen as reference sequences, while other second-level indices were selected as comparative sequences. Statistical data were primarily sourced from regional medicine logistics data spanning 2020 to 2021.

All negative storage indices in the original data were considered negative correlation indexes. For example, greater forest coverage and higher levels of informatization correlated with lower carbon emissions. These negative correlation indexes underwent orthogonalization during data processing, followed by the transformation of the original data into dimensionless form using a specific formula. Grey relational coefficients between carbon emissions of the logistics industry in Shanxi Province and 38 selected factors were calculated based on a prescribed formula. Finally, the grey relational degree of medicine logistics in the region was determined according to a specific formula, as presented in Table 2.

Grey Relational Analysis Results

The grey relational degrees between the regional medicine logistics industry growth and each of the first-level indices are ranked in decreasing order as follows: Transportation risk > Site facilities and equipment > Operation risk > External environment. Furthermore, the grey relational degrees between second-level indexes are ranked in descending order as follows: Refrigeration equipment > Staff technology > Processing equipment > Cleaning of equipment and tools > Supply capacity > Market demand fluctuation > Damage rates of goods > Processing equipment > Storage design > Monitoring strength > Inventory information system > Picking efficiency > Route planning > Loading and unloading methods > Cleaning equipment and monitoring facilities > Purchasing varieties and attributes > Distribution efficiency > Picking methods > Storage temperature > Operation standards > Refrigeration vehicles > Location of goods > Packaging technology > Supplier management system > Sharing extent and authenticity of information > Network layout and distribution efficiency > Integrity of suppliers > Qualification of third-party enterprises > Storage methods > Ordering plan > Ordering period > Place cleaning > Packaging level division > Storage quantity > Staff awareness > Storage time > Training and assessment of staff > Temperature control equipment.

Analysis of Grey Relational Coefficients

The grey relational coefficients of the four first-level indices exceeded 0.5, indicating a strong relationship between the selected parameters and the growth of the pharmaceutical logistics sector. Transportation risk exhibited the highest grey relational degree for the medicine logistics industry's growth (0.984), followed by site facilities and equipment (0.764), underscoring their significant contributions.

Operation risk exhibited the lowest grey relational degree for the medicine logistics industry's growth, registering at 0.721. The external environment secured fourth place with a grey relationship degree of 0.5462. Notably, site facilities and equipment, transportation risk, and operation risk all boasted correlation coefficients exceeding 0.7, underscoring

their substantial influence on the growth of the region's medical logistics sector.

DISCUSSION

Changes in the production or logistics services of medicines consistently encounter challenges. Given the competitive nature of the healthcare industry, hospitals now prioritize patient satisfaction, operational efficiency, and cost reduction. The value of SC is widely recognized, with the understanding that involvement from SC partners enhances the network's efficiency and effectiveness.[6]

Establishing timely access to external resources and mitigating operational volatility require well-coordinated relationships with suppliers and customers.[3] Therefore, considerable research has been conducted on how various factors in the supply chain contribute to operational performance.[6-8] While reducing operational expenses is a significant advantage of streamlined logistics management, it also enhances overall performance, medical services, and patient satisfaction.[8]

The pharmaceutical logistics sector on the Chinese mainland has witnessed significant growth in recent years.[6-8] Various studies conducted by local scholars have highlighted its importance as a critical societal issue. Conducting comprehensive research on hospital pharmaceutical logistics systems is imperative for enhancing their overall capabilities, core competitiveness, and internal support infrastructure.[8,9]

Addressing Challenges in Medicine Transportation Logistics

Managing the logistics of transporting medicines is particularly challenging due to factors like frequent batches, small volumes, and rapid aging of products. Customizing refrigerated trucks with multiple temperature control systems can address these challenges and meet the diverse needs of transporting different medications.[7] Multiple temperature control zones, including low temperature, refrigeration, and frozen areas, can be incorporated into refrigerated vehicles to facilitate widespread distribution and enhance efficiency at scale.[8] When designing a medical cold chain logistics information platform, considerations should include developing a system that aligns with the specific characteristics of Chinese practices while leveraging insights from international models.[7,8]

Instead of overly depending on foreign scientific research findings, relevant ministries in China should consolidate technological resources to develop domestic logistics information platforms. With government supervision and promotion, we can pursue a path of marketization and embrace market-oriented approaches to accelerate the development of China's medical cold chain logistics information infrastructure.

Electronic Data Exchange (EDI) in Pharmaceutical Logistics

Electronic data exchange (EDI) holds the potential to enhance productivity and reduce costs within the logistics process through the establishment of logistics information platforms. As online shopping continues to grow, it becomes increasingly essential for advancements in pharmaceutical delivery logistics to align with this trend. To facilitate EDI connections to customer databases and warehouse management systems, businesses require comprehensive inventory and distribution management systems that enable real-time online monitoring and planning of the inventory cycle and replenishment.[9]

Addressing Challenges in Hospital Drug Logistics Management

In hospital drug logistics management, effective handling of SC data is crucial for efficient operations. Hospitals often manage their own purchasing departments, pharmacies, and internal distribution networks, acting as intermediaries in the order fulfillment process. However, this decentralized approach results in high inventory and storage costs due to numerous transactions with various suppliers and departments. Moreover, logistical responsibilities are often fragmented across different departments, leading to coordination challenges and integration issues that need to be addressed promptly.[3,10]

Risk Identification and Analysis

In this study, we conducted a comprehensive review of the existing literature to ascertain the significance of the research topic. Subsequently, we performed an in-depth analysis of the medicine logistics system, focusing on its pivotal processes: transportation, storage, distribution, and quality management. We then identified and summarized a total of 38 associated risks. Utilizing grey relational analysis, we categorized these risks into four distinct categories. Finally, we proposed specific risk control methods tailored to each category, including strategic investments in infrastructure, information platforms, and e-commerce solutions for pharmaceuticals.

This study not only establishes a solid foundation for managing medicine logistics but also offers valuable insights applicable to similar medical enterprises. While previous research in China has predominantly been qualitative, this study addresses the current state and challenges of medical cold chain logistics management, offering practical solutions.[11] This study aimed to enhance firm management by stratifying risk variables based on regional logistics industry operations and employing scientific methods.

Enhancing Medicine Logistics Operations

Medicine logistics involves a multitude of procedures aimed at intervention, efficiency, quality, and safety, all of which require enhancement.[12] This imperative arises from fundamental core factors necessitating a shift in the management approach of medical facilities. In transitioning towards a corporatized healthcare model, the competitive market paradigm is being applied to the national healthcare system. Hospitals are now required to operate with financial and managerial independence, establishing their objectives for service quality and cost control.[13,14]

Limited resources and escalating costs underscore the need for a rationalized approach to public health, especially to address increasing quality demands. This situation calls for substantial changes not only in diagnostic and treatment procedures but also in support processes, particularly logistics, which play a vital role in service differentiation and quality enhancement.

Study Limitations

While this study provides valuable insights into medicine logistics management, it has a few limitations. Firstly, the selection and categorization of risk variables may have been subjective, potentially affecting the comprehensiveness of the analysis. Additionally, the choice of model and analytical methodologies could influence the outcomes and interpretations of the findings. Furthermore, the absence of specific constraints at both the study and author levels may have introduced biases or oversights. These limitations highlight the need for cautious interpretation of the results and suggest avenues for future research to address these shortcomings.

CONCLUSION

In conclusion, this study employed Grey relational analysis to discern and classify the principal risks and detrimental factors influencing medicine logistics, suggesting specific risk mitigation strategies to enhance efficiency and quality in healthcare logistics. Emphasizing the urgency for systematic reforms in healthcare logistics to tackle escalating costs and quality requirements, our results provide valuable guidance for refining operational procedures and shaping future research endeavors in this domain.

COMPETING INTERESTS

The authors report no conflict of interest.

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AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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