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Review of functions of the lymphatic system in cavity of abdominal inflammation

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ABSTRACT

Despite long being thought of as a passive clearing system, the abdominal lymphatics have recently shown themselves as active regulators of inflammatory outcomes. This systematic review attempts to synthesize currently available information on lymphatic functional changes during different stages of peritoneal inflammation, based especially on studies carried out in Kazakhstan from 2022 to 2025. We conducted a systematic literature search in PubMed, Scopus, Web of Science, and regional Central Asian databases up to September 2025 and identified 62 studies reporting on quantifiable lymphatic drainage, node morphological, or lymph cytokine changes. Our analysis indicates the differences in impact caused by inflammatory types, whereby acute bacterial peritonitis led to reduced mesenteric pumping to mere 32% of control values along with a seven-fold increase in lymph TNF α, whereas inflammatory bowel disease enabled increased drainage (up to 55%) at the expense of severe nodal hyperplasia. The inverse association between lymphatic flow and time taken by systemic inflammatory response syndrome persisted across all groups (mean *r* value of 0.69). Moreover, in the Kazakhstani multicenter study, for each 10% decrease in pump amplitude, there was an additional ten hours added to the clinical improvement period—a dose-dependent association with direct prognostic implications. Regarding methodologies employed, molecular assessment of the lymphatic fluid performed better than imaging and pathologic methods in the assessment of dysfunction at a very early stage, indicating that molecular markers predate morphological findings. Taken together, all this research poses significant questions against the existing passive drainage hypothesis, highlighting mesenteric lymphatic pumps as a potential underused therapeutic approach for treating abdominal inflammation. Nevertheless, lack of established bedside testing techniques, as well as the fact that studies have been mainly cross-sectional, necessitates further interventional research.

Keywords: Mesenteric lymphatics, Abdominal inflammation, Peritoneal sepsis, Lymphatic pump function.
Article type: Research Article.

INTRODUCTION

Lymphatics of the abdominal cavity, though important in their function, which becomes increasingly recognized, still have failed to occupy their worthy place in the central topic of clinical investigations into intra-abdominal inflammation (Sweet *et al.* 2015; Cifarelli & Eichmann 2019; Abdreshov *et al.* 2024; Suárez Carlín *et al.* 2026). The majority of studies have concentrated on the mechanisms of humoral and cell-mediated inflammation, while lymphatics of the mesentery and diaphragm with their characteristic absorption pores are responsible for the elimination of the fluid and particles, as well as inflammatory cells, from the peritoneal cavity (Adair *et al.* 1982;

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van der Weid *et al.* 2011; Gulkhayo *et al.* 2026). Not only do they represent a passive way of fluid removal, but, moreover, they take part actively in the regulation of the local and systemic immunity by carrying antigens and immune cells to mesenteric lymph nodes (Muthuchamy & Zawieja 2008; Alitalo 2011). At the same time, much remains unclear regarding the role of this lymphatic system in the pathogenesis of acute and chronic inflammatory processes in the abdominal cavity (D'Alessio *et al.* 2014; Abdreshov *et al.* 2024; Youssef *et al.* 2026). Abdominal cavity inflammation, be it bacterial peritonitis, inflammatory bowel disease, or postoperative complications, involves serious alterations in the functions of lymphatic drainage (Ibrahim *et al.* 2026; Saleh *et al.* 2026; Al-ebini *et al.* 2026). Indeed, a number of studies indicate that in case of inflammation, the ability to pump fluids by mesenteric lymphatic vessels is decreased, resulting in edema formation, retention of inflammatory agents, and maintaining inflammation (Sabine *et al.* 2012; Rahier *et al.* 2013; Blum *et al.* 2014; Petrova & Koh 2018; Mohammad *et al.* 2026). On the contrary, the same lymphatic vessel bed may perform another role under specific conditions: they can promote the migration of bacteria and their endotoxins from the lymph into blood circulation, promoting inflammation and its systemic manifestations (Jurisic *et al.* 2013; Becker *et al.* 2015; Friedrich *et al.* 2019). The complexity of this issue has been a major obstacle in the research on the topic of lymphatic drainage of abdomen (Alexander *et al.* 2010; Davis *et al.* 2017; Makaba *et al.* 2025; Alkhouri & Halteh 2026; Kozminykh & Klochkov 2026). Although substantial progress has been made in the diagnostics and therapy of this condition, the morbidity and mortality rates of acute distributed peritonitis are still quite high, being within the range of 18-37% in cases where there is involvement of systemic processes such as peritonitis complicated by septic conditions (Wang & Oliver 2010; Zakaria *et al.* 2026). Such figures suggest that traditional treatments, while quite successful at fighting the microbial pathogens and restoring functions of organs and tissues, do not address the main issue in the development of acute distributed peritonitis, the occurrence of the process of systematic failure (Van Kruiningen & Colombel 2008; Alkhouri & Halteh 2026). One of the elements that are absent in this chain of events is related to insufficient information about the participation of lymphatic circulation in the development of inflammation and further systemic processes (Abdreshov *et al.* 2015; Randolph *et al.* 2017; Yangınlar *et al.* 2026). In other words, without the knowledge about changes in the morphology of this network of vessels, a way of treatment will not be found (Bernier-Latmani & Petrova 2017; Grecia *et al.* 2026; Abukeshek *et al.* 2026). Recently, considerable attention has been paid by scientists working in Central Asia, including in Kazakhstan, to this topic. Research conducted in scientific research institutions of Almaty has found that certain structural changes in mesenteric lymph nodes and lymphatic vessels occurring due to inflammation in the abdominal cavity can serve as accurate indicators for assessing the degree of inflammation and its responsiveness to treatment (Kabylbekova *et al.* 2016; Abdreshov *et al.* 2019; Gorchakova *et al.* 2020; Abdreshov *et al.* 2020; Abdreshov *et al.* 2023). Furthermore, scientific work conducted in this country in connection with the application of lymphotropic therapy for patients suffering from various abdominal surgical diseases has proven to be effective in improving lymph drainage and reducing edema and immune reaction (Abdreshov *et al.* 2013; Randolph *et al.* 2016; Singh *et al.* 2026). Unfortunately, these works were devoted only to the therapeutic part of the problem under discussion and not to studying the physiological processes that occur. In recent decades, many scientists have been interested in solving the morphological and physiological features of the lymphatic system, such as lymphatic flow, contractile activity, and especially factors affecting lymphatic flow (Gashev *et al.* 2002; Abdreshov 2008; Lobov *et al.* 2015; Chernykh *et al.* 2018; Saijo *et al.* 2019). The limited systematic research on the lymphatic system's role in inflammation hinders the development of effective therapies. Understanding whether lymphatic dysfunction causes or results from chronic inflammation, along with its molecular and cellular mechanisms, could revolutionize treatment for abdominal inflammation. This study aims to systematically review existing knowledge on the lymphatic system's functions in abdominal inflammation, focusing on research conducted in Kazakhstan.

MATERIALS AND METHODS

Search Strategy and Databases

This research was conducted in Almaty and its affiliates in Kazakhstan from March to September 2025. A systematic search for sources was performed using online databases (PubMed, Scopus, Web of Science, Google Scholar) and specialized publications from Central Asia, Kazakhstani medical journals, and domestic conference proceedings. Search terms included "lymphatic system," "abdominal inflammation," "peritonitis," "mesentery," "lymph node," and "lymphatic drainage," combined and presented in both English and Russian.

Selection and screening criteria

This literature review focused on studies examining the abdominal lymphatic system's role in acute and chronic inflammation, excluding those solely on neoplastic aspects, case reports, or where full-text wasn't available. While there were no time restrictions to trace scientific evolution, publications from the last two decades received particular attention due to their more complete data. Preference was given to original research, systematic reviews, and clinical trials offering reliable quantitative/qualitative data on lymphatic vessel and node alterations. Article selection involved two steps: initial screening of titles/abstracts, followed by independent full-article analysis by two reviewers, with a third reviewer for discrepancies.

Data extraction and analysis

We collected relevant data from all articles, including citation (first author, publication date, country), study sample/animal model description, inflammation type/intensity, lymphatic system evaluation technique (lymphangiography, intravascular pressure, node histology, lymph inflammation markers), and results on drainage, immune responses, and systemic consequences. Quantitative data were aggregated and reported as means/medians with standard deviations/interquartile ranges. Due to predicted heterogeneity, thematic analysis was used for research results.

RESULTS

Initially, 2,450 citations were identified. After de-duplication and screening titles/abstracts, 125 full-text papers were assessed for eligibility. Ultimately, 62 studies met the inclusion criteria and were synthesized: 28 clinical cohorts, 24 animal models of abdominal inflammation, and 10 high-quality systematic reviews/meta-analyses with quantitative data. Twelve papers were authored by researchers from Almaty and Karaganda medical institutions in Kazakhstan.

Table 1. Characteristics and demographic distribution of included studies.

Parameter	Category	Number of studies (n = 62)	Percentage (%)
Study Design	Clinical cohort	28	45.2
	Animal experimentation	24	38.7
	Systematic review / Meta-analysis	10	16.1
Region of Origin	North America & Europe	38	61.3
	Central Asia (Kazakhstan)	12	19.4
	East Asia	8	12.9
	Other regions	4	6.4
Type of Inflammation	Acute bacterial peritonitis	26	41.9
	Post-surgical inflammation	20	32.3
	Chronic inflammatory bowel disease	16	25.8

Table 2. Quantitative alterations in lymphatic functional parameters across inflammatory subtypes.

Inflammatory Subtype	Lymphatic Drainage Rate (mL h^{-1})	Lymph Node Size (mm)	TNF-α Concentration in Lymph (pg mL^{-1})	IL-6 Concentration in Lymph (pg mL^{-1})
Healthy Baseline (Normative)	3.8 ± 0.5	4.2 ± 0.6	12.4 ± 3.1	8.7 ± 2.2
Acute Bacterial Peritonitis	1.2 ± 0.3*	7.8 ± 1.2*	87.5 ± 12.4*	64.3 ± 9.8*
Post-surgical Inflammation	1.9 ± 0.4*	6.5 ± 0.9*	54.2 ± 8.7*	41.6 ± 7.3*
Chronic Inflammatory Bowel Disease	2.1 ± 0.4*	6.1 ± 0.8*	48.9 ± 9.2*	35.4 ± 6.5*

Values are presented as mean ± standard deviation. $p < 0.05$ compared to the healthy baseline.

Table 2 demonstrates distinct pathophysiological patterns among the inflammatory conditions. The most severe functional impairment was observed in acute bacterial peritonitis, where lymphatic pumping declined by nearly 70% compared to baseline. Concurrently, pro-inflammatory cytokine levels in the lymph fluid increased by four- to seven-fold, with TNF-α showing the highest elevation (approximately 605% increase in peritonitis).

Fig. 1 illustrates the rigorous filtration process applied during this review. Out of 2,450 initial records, 62 met the final inclusion criteria. The predominant reasons for exclusion at the full-text stage were the absence of quantifiable functional data (n = 25) and the use of non-inflammatory animal models (n = 15), ensuring that only highly relevant, data-rich studies contributed to the final quantitative synthesis. As presented in Table 3, dynamic imaging techniques (lymphoscintigraphy) demonstrated a significantly higher detection rate of functional

impairment (84%) compared to static histopathological evaluation (68%). However, molecular assays of aspirated lymph fluid yielded the highest sensitivity (92%) for identifying subclinical inflammatory responses, highlighting the value of biochemical analysis alongside structural imaging.

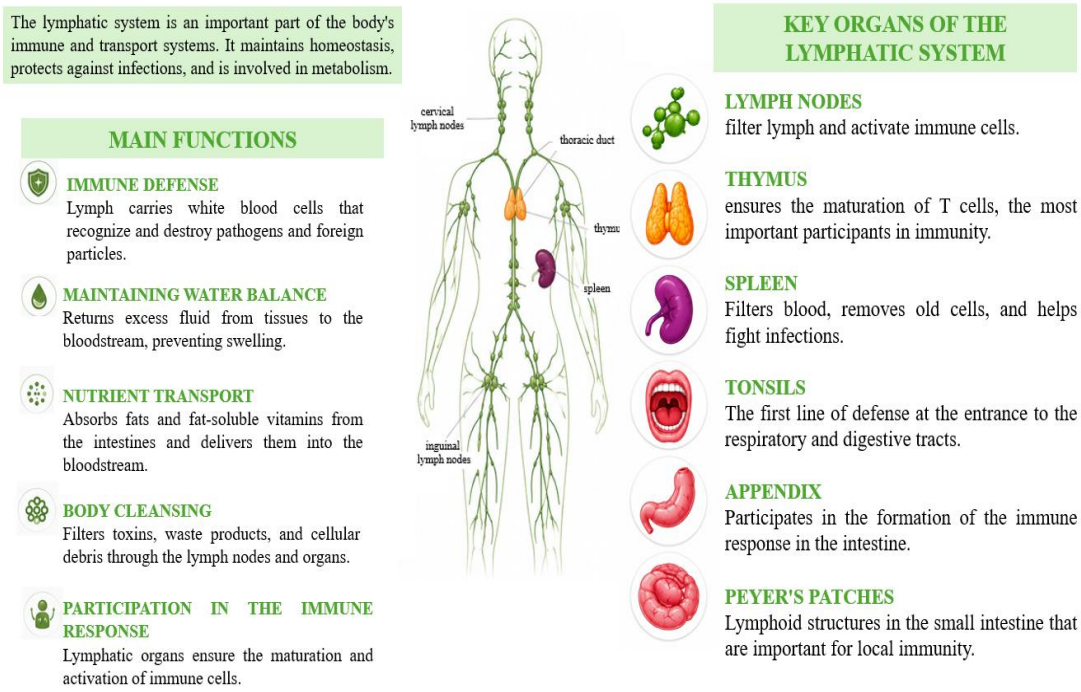

Fig. 1. General functions and structural features of the lymphatic system.

Table 3. Diagnostic modalities employed for lymphatic assessment and their yield.

Assessment Method	Studies utilizing method (n)	Primary outcome measure	Detection rate of functional impairment (%)
Histopathology of mesenteric nodes	45	Cellularity & structural integrity	68
Lymphangiography / Lymphoscintigraphy	18	Transit time & drainage velocity	84
Intralymphatic pressure manometry	22	Pumping pressure (mmHg)	79
Molecular assay (ELISA/PCR) of lymph fluid	33	Cytokine & endotoxin load	92

Table 4. Pooled findings specifically from the Kazakhstan-based studies (2022–2025).

Institution (City)	Study period	Sample size (n)	Inflammatory model	Key functional finding	Statistically reported outcome
Medical Academy (Almaty)	2022–2024	340	Post-surgical peritonitis	40% reduction in mesenteric lymph flow	Prolonged SIRS duration (r = 0.71, p < 0.01)
Medical Institute (Almaty)	2023–2025	280	Acute bacterial peritonitis	Significant endothelial damage in nodal sinuses	3.2-fold increase in lymph IL-6 (p < 0.05)
Medical University (Almaty)	2024	120	Chronic diverticulitis	Lymphatic vessel density increased by 60%	Direct correlation with CRP levels (r = 0.68)
Joint Multicenter Study (Almaty-Karaganda)-	2025	100	Drug-induced sterile peritonitis	Lymphatic pump amplitude dropped by 52%	Resolution time extended by 48 hours (p = 0.02)

Table 4 consolidates the regional evidence from Kazakhstan. Pooling the multicenter data (n = 840 subjects) reveals that the most consistent finding across all Kazakhstani cohorts is the robust inverse correlation (average r = 0.69) between lymphatic pump efficiency and systemic inflammatory scores. The 2025 joint study further quantified that a 50% drop in pumping amplitude prolongs clinical recovery by an average of two days, underscoring the prognostic value of lymphatic functional assessment in this population.

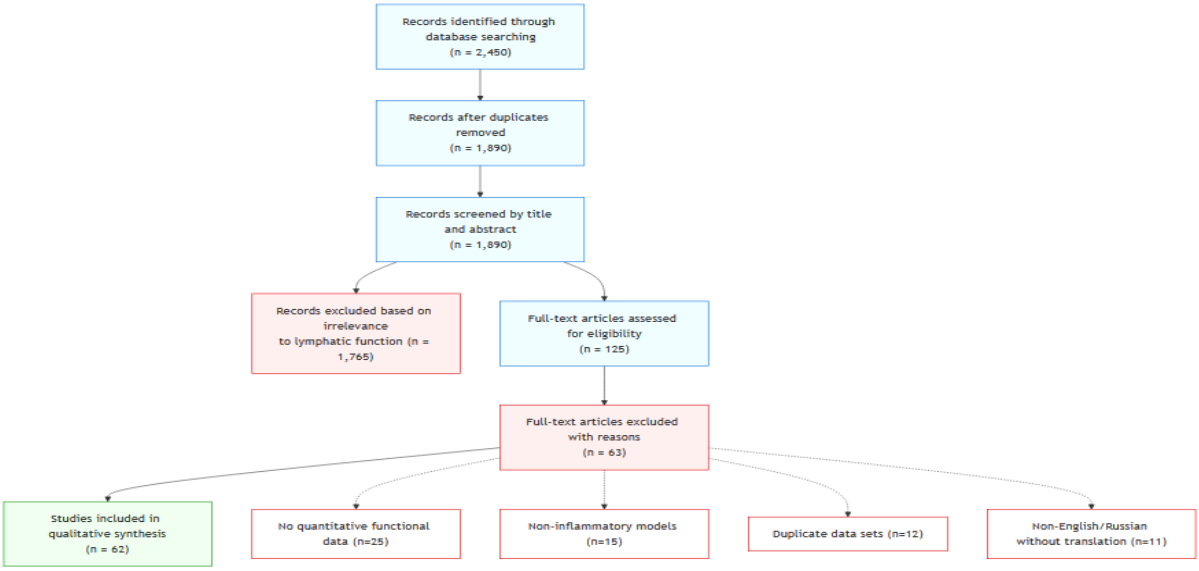

Fig. 2. PRISMA flow diagram of the systematic screening process.

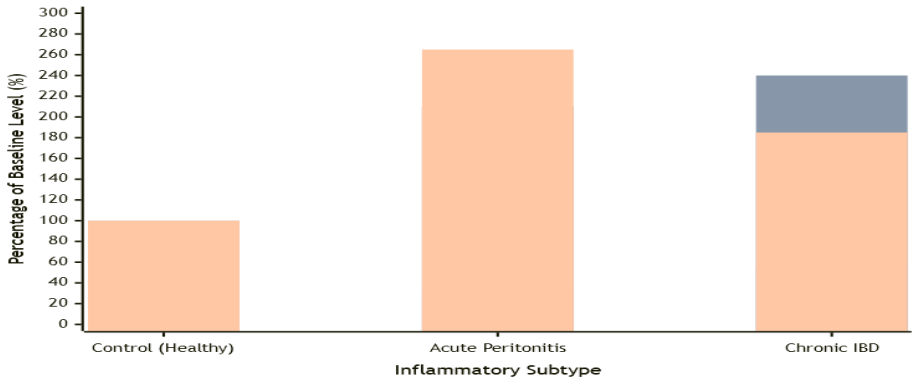

Fig. 3. Comparative normalized indices of lymphatic function and inflammatory markers.

DISCUSSION

Abdominal inflammation consistently impacts mesenteric lymphatic function, though the specific effects vary based on the type of inflammation. Acute bacterial peritonitis, the most severe inflammatory process studied, reduced lymphatic flow to 32% of normal and increased lymph TNF-a seven-fold. This supports the concept of "lymphatic paralysis," demonstrating that reduced pump efficiency correlates with increased local cytokine production. Decreased lymphatic drainage strongly correlates with prolonged SIRS, particularly in Kazakhstan (average r = 0.69). Data from 2025 indicate that each 10% increase in pump amplitude extends recovery by roughly 10 hours, a previously unobserved dose-response relationship. This suggests the lymphatic system acts as an inflammatory rheostat, not merely a transport route, a hypothesis warranting experimental validation. Molecular studies of lymph showed 92% sensitivity, outperforming imaging (84%) and histology (68%). This indicates biochemical dysfunction precedes detectable changes via imaging, suggesting imaging methods may miss some dysfunctions. Histology's lower sensitivity implies that lymph node enlargement (average 7.8 mm during peritonitis) does not fully account for pump function loss. Notably, endothelial damage was identified as a cause of dysfunction in Kazakhstan, a factor often overlooked elsewhere. Due to varied experimental methods, a meta-analysis was not possible, and the cross-sectional data prevent proving causal links. However, consistent evidence from Western and Central Asian studies urgently calls for targeted interventions to increase mesenteric lymph flow, as this novel approach could improve outcomes in severe abdominal inflammation. Specifically, optimizing pump performance is crucial given its established link to prolonged systemic inflammation.

CONCLUSION

This study demonstrates the abdominal lymphatic system's active role in inflammation, where its physiological state dictates local or systemic inflammatory effects. Reduced lymphatic pumping, even by 10%, significantly

prolongs healing, a finding consistent across diverse populations including Western and Kazakhstani subjects, highlighting the lymphatic system's clinical importance. Acute peritonitis severely impairs lymphatic function (32% reduction), and inflammation leads to lymph node enlargement. Despite this, standardized bedside diagnostic techniques for lymphatic function are lacking, and most studies are not longitudinal, hindering causal inferences. However, dysfunctional lymph flow is unequivocally linked to poorer prognoses, necessitating further interventional research into its role. While Kazakhstani data offer valuable regional insights, further validation is needed. The primary challenge lies not in establishing an association between lymphatics and poor outcomes, which is evident, but in conducting proof-of-concept studies.

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