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REVIEW ARTICLE

Hemoadsorption in Emerging Economies: Translating Therapeutic Promise into Clinical Practice

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ABSTRACT

Critical illness and sepsis place a substantial burden on emerging healthcare systems, where delayed presentation and referral, limited diagnostic and monitoring capacity, a high burden of antimicrobial resistance, variable intensive care and extracorporeal infrastructure, workforce shortages, and substantial out-of-pocket healthcare costs may complicate the management of septic shock. Prompt antimicrobial therapy, source control, hemodynamic stabilization, and organ support remain the foundation of care; however, some patients develop persistent shock and progressive organ dysfunction despite optimized conventional treatment. In this context, hemoadsorption has emerged as a potential adjunctive therapy aimed at modifying components of the dysregulated host response.

Despite its biological rationale and effects on circulating inflammatory mediators, improvements in surrogate markers have not consistently translated into better patient outcomes. Important uncertainties regarding optimal patient selection, timing, and treatment intensity therefore remain. A pragmatic approach in emerging economies should prioritize carefully selected patients with persistent vasopressor-dependent shock, progressive organ dysfunction and a clinically relevant hyperinflammatory phenotype despite optimized standard care. Treatment decisions should be guided primarily by clinical presentation and trajectory rather than rigid time thresholds or reliance on a single biomarker. Multidisciplinary assessment, transparent communication regarding potential benefits, limitations, uncertainties, risks, and financial implications, and predefined clinically meaningful endpoints are essential. Serial reassessment should guide treatment continuation, modification, or cessation. Prospective documentation of outcomes, complications, resource utilization, and affordability is needed to strengthen locally relevant evidence. Ultimately, the value of hemoadsorption in emerging economies will depend on its appropriate, equitable, and context-sensitive integration into existing healthcare systems.

Key words: *Emerging economies, hemoadsorption, resource-limited settings, sepsis, septic shock.*

INTRODUCTION

Critical illness places a substantial burden on emerging economies, where limitations in intensive care capacity, workforce, monitoring, and access to advanced organ-support technologies may constrain the delivery of optimal care.[1–3] Sepsis and septic shock are particularly challenging in these settings, where a high burden of antimicrobial resistance (AMR), limited access to rapid microbiological diagnostics, and prolonged turnaround times for culture and susceptibility results may complicate the timely selection and optimization of antimicrobial therapy.[4,5] Moreover, delayed recognition, fragmented referral pathways, and delayed access to definitive critical care may result in presentation with advanced shock and established organ dysfunction.[6,7] Prompt antimicrobial therapy, source control, hemodynamic stabilization, and organ support remain the foundation of sepsis management.[8,9] Nevertheless, some patients develop persistent shock and progressive organ dysfunction despite optimized conventional treatment. This has generated interest in adjunctive therapies targeting components of the dysregulated host response.

Hemoadsorption with CytoSorb® (CytosorbentsInc, New Jersey, U.S.) or Oxiris (Baxter India Private Limited, India) can remove a range of circulating molecules, including inflammatory mediators, bilirubin, and myoglobin.[10–13] However, biological plausibility and reductions in circulating mediators should not be equated with guaranteed improvement in patient-centered outcomes. The challenge, therefore, is not simply whether hemoadsorption can be delivered, but how it can be integrated responsibly into healthcare settings with heterogeneous resources, infrastructure, and affordability.

This review examines the practical translation of hemoadsorption into emerging economies, focusing on patient selection, timing, treatment delivery, monitoring, treatment intensity, and context-sensitive implementation.

DISCUSSION

Therapeutic Rationale and Relevance

Sepsis involves a dysregulated host response characterized by inflammation, endothelial dysfunction, vasoplegia, and cellular and metabolic abnormalities that may culminate in shock and multiple organ dysfunction.[14] In patients who remain unstable despite appropriate antimicrobial therapy, source control, hemodynamic optimization, and organ support, adjunctive strategies may be considered.

CytoSorb® hemoadsorption can remove circulating inflammatory mediators and other potentially harmful molecules.[13,15] However, reductions in inflammatory mediators alone do not necessarily establish meaningful clinical benefit. Hemoadsorption should therefore not be considered routine therapy for all patients with sepsis. Its potential role lies in the targeted treatment of carefully selected patients with hyperinflammation and persistent or progressive critical illness despite optimized standard care. International best-practice recommendations and the Indian expert consensus emphasize individualized patient selection, timing, and treatment goals.[15,16]

This distinction is particularly important in emerging economies, where cartridge costs, technical expertise, monitoring capacity, and availability of extracorporeal infrastructure may limit implementation. The objective should therefore be even more selective and clinically meaningful use rather than broader utilization.

Challenges of Translation into Emerging Economies

The implementation of hemoadsorption must account for challenges extending beyond the device itself. Low- and middle- income countries bear a substantial burden of AMR and often face limited healthcare-system capacity to address it.[4,5,17] In addition, diagnostic gaps and limited access to timely pathogen identification and antimicrobial susceptibility testing may complicate targeted antimicrobial therapy and prolong empirical broad-spectrum treatment.[18] In a recent multinational survey, clinicians identified inadequate laboratory infrastructure, limited rapid diagnostics, and prolonged turnaround times as important barriers to antimicrobial stewardship, with lack of 24-hour microbiology laboratories particularly reported in India.[19] Delays in referral[20] and source control[8] may further compound disease progression and it is important to acknowledge that hemoadsorption cannot substitute for infection control; timely antimicrobial therapy and definitive source control remain fundamental to sepsis management.

These challenges may, however, create a rationale for considering adjunctive therapies in appropriately selected patients who continue to deteriorate despite optimized standard care. Hemoadsorption may contribute to hemodynamic stabilization and modulation of circulating inflammatory mediators, potentially supporting the management of refractory shock until definitive therapies take effect. Importantly, this remains a biologically plausible and clinically evolving strategy rather than proven evidence that hemoadsorption can "bridge" delays in antimicrobial identification or source control.[15,16]

Equally important is the optimization of standard care. Excessive fluid accumulation and unnecessarily prolonged exposure to broad-spectrum antimicrobials can cause harm and increase healthcare costs, reinforcing the need for frequent reassessment and individualized treatment rather than indiscriminate escalation.[8,19] Whether hemoadsorption can reliably reduce requirements for fluids, vasopressors or organ support remains to be confirmed in upcoming larger studies. In any way its role should be to complement and—not replace—careful optimization of these fundamental therapies.

Timely patient selection, technical feasibility, and affordability

remain additional barriers. Treatment decisions should therefore be individualized; integrating the clinical trajectory, available infrastructure, expertise, and local economic realities. Table 1 summarizes the clinical challenges and proposes pragmatic approaches to support contextually appropriate implementation.

Table 1. Key Challenges and Pragmatic Approaches to Hemoadsorption in Emerging Economies

Key challenge	Relevance in emerging economies	Pragmatic clinical approach
1. Delayed presentation and optimization of standard care	Delayed recognition and referral may result in presentation with advanced shock and organ dysfunction, while timely delivery of antimicrobials, source control, hemodynamic stabilization, and organ support may be challenging.[6,8]	Optimize standard sepsis care before considering hemoadsorption. Treatment decisions should consider the patient's clinical trajectory rather than a rigid time threshold.[8,21]
2. Appropriate patient selection and timing	Limited diagnostic and phenotyping resources may complicate the identification of patients most likely to benefit, while delays related to referral and logistics may affect treatment timing.[18]	Consider hemoadsorption in selected patients with persistent vasopressor-dependent shock, progressive organ dysfunction, or a clinically relevant hyperinflammatory phenotype despite optimized care. Early treatment should be considered within the local clinical context.[15,16]
3. Limited access to biomarkers and monitoring	IL-6 and other specialized biomarkers, as well as advanced hemodynamic monitoring, may be unavailable, costly, or delayed.[15]	Base treatment decisions primarily on clinical assessment and disease trajectory. Use feasible endpoints such as vasopressor requirements, hemodynamic stability, lactate trajectory, and organ function.[15,16,22]
4. Extracorporeal infrastructure and technical expertise	Access to CRRT, extracorporeal platforms, consumables, and trained personnel varies substantially between centers.[23]	Integrate hemoadsorption into existing extracorporeal infrastructure where feasible and adapt treatment protocols to local technical expertise and capacity.[15]
5. Treatment intensity and reassessment	Cartridge availability and costs may constrain treatment duration, while no validated fixed treatment "dose" or number of cartridges has been established.[15,22]	Define treatment goals before initiation and reassess the clinical response serially to guide continuation, modification, cartridge replacement, or cessation of therapy.[15,16,22]
6. Affordability and communication with families	Treatment decisions may occur under considerable emotional and financial pressure, particularly where patients and families bear a substantial proportion of healthcare costs.[24]	Discuss the rationale, potential benefits, limitations, uncertainties, risks, treatment burden, and financial implications transparently and incorporate patient and family values into decision-making.[24–26]
7. Limited locally relevant evidence	Most evidence and recommendations originate from healthcare settings with different resources, infrastructure, and referral pathways.[15]	Adapt rather than directly adopt international recommendations and prospectively document clinical outcomes, complications, resource utilization, and affordability to generate locally relevant evidence.[15,21]

Abbreviations: CRRT, continuous renal replacement therapy; IL-6, interleukin-6.

Recent updates: Translating Evidence into Bedside Decisions

Several practical questions remain when translating the biological rationale and evolving evidence for hemoadsorption into bedside practice. The following considerations address key uncertainties related to patient selection, timing, monitoring, treatment intensity, and communication within the context of emerging healthcare settings.

1. How early is early enough?

The optimal timing of hemoadsorption remains uncertain. International best-practice recommendations support early consideration in appropriately selected patients with septic or vasoplegic shock, while the Indian expert consensus recommends initiation within 24 hours after diagnosis and commencement of standard therapy in selected patients with refractory septic shock.[15,16]

Published experience from India supports the feasibility of early treatment strategies[25,27,28], although comparable evidence from other emerging economies such as Bangladesh, Sri Lanka remains limited to case-based reports. Evidence from Latin America is also emerging but remains insufficient to establish clinical efficacy. Treatment should not be unnecessarily delayed once an appropriate indication has been established; however, rigid timing thresholds may not be applicable across diverse healthcare settings.[21]

2. How should clinicians communicate with patients' families?

Specific guidance regarding family communication about hemoadsorption remains limited. An Indian prospective multicenter study reported obtaining informed consent after discussion of the potential advantages and disadvantages of therapy with patients or their relatives.[25] Broader critical care guidance supports shared decision-making that integrates the best available evidence with patient values and preferences.[26]

Before treatment is discussed with families, the clinical team should establish a shared understanding of the indication and therapeutic goals. Families should understand that hemoadsorption is an adjunctive therapy with a biological rationale but has uncertain effects on major clinical outcomes. Discussions should address potential benefits, limitations, risks, treatment burden, and financial implications.[13,24,29]

3 Is IL-6 measurement necessary?

IL-6 measurement should not be mandatory before initiating hemoadsorption. The Indian expert consensus recommends that treatment decisions be guided primarily by the clinical presentation and trajectory of refractory septic shock, particularly because IL-6 testing may be unavailable or delay time-sensitive intervention.[15] International recommendations similarly emphasize clinical assessment, with biomarkers providing supportive rather than decisive information.[16,22]

Other readily available biomarkers may contribute to clinical assessment, but no validated biomarker threshold currently identifies patients most likely to benefit. Biomarkers should therefore complement clinical judgment rather than delay treatment when an appropriate indication has been established.

4. Should treatment wait until acute kidney injury develops?

Acute kidney injury (AKI) or the need for renal replacement therapy (RRT) should not be considered prerequisites for hemoadsorption. Both the Indian expert consensus and international recommendations emphasize the clinical phenotype and trajectory of refractory shock rather than the occurrence of a specific organ complication.[15,16,22] Although hemoadsorption is frequently incorporated into an existing RRT circuit, the requirement for renal support should not determine treatment eligibility. Where alternative extracorporeal delivery platforms are available, their technical feasibility, infrastructure requirements, personnel expertise, and cost should be considered within the local healthcare context.

5. Which clinical endpoints should be monitored?

Treatment response should be assessed using serial clinical and physiological endpoints rather than reductions in inflammatory biomarkers alone. Relevant indicators include hemodynamic stability, vasopressor requirements, lactate trajectory, and organ function.[15,16,22]

In resource-constrained settings, a limited number of feasible and clinically meaningful endpoints may be preferable to complex monitoring strategies. Biomarker changes should be interpreted as supportive information rather than evidence of clinical efficacy.

6. How many adsorbers are required?

There is currently no validated fixed number of adsorbers or evidence-based treatment "dose," and important variables such as treatment duration and cartridge replacement remain incompletely defined.[16,22] Published Indian experience demonstrates heterogeneity in treatment strategies and reliance on individualized clinical assessment, supporting a patient-specific approach to treatment intensity.[25,27,30] Therefore, in resource-constrained settings, continued treatment should be supported by an ongoing clinical rationale and predefined therapeutic goals. Prospective studies are required to establish optimal treatment intensity and cost-effectiveness.

A pragmatic implementation framework

A context-sensitive implementation model should begin with prompt optimization of standard sepsis care, including antimicrobials, source control, hemodynamic stabilization, and organ support.[8] Hemoadsorption may subsequently be considered in selected patients with persistent vasopressor-dependent shock, progressive organ dysfunction and clinically relevant hyperinflammatory phenotype despite optimized care.[15,16]

Before initiation, multidisciplinary discussion should address the indication, treatment goals, technical feasibility, limitations, and anticipated financial burden. Families should receive balanced information regarding potential benefits, uncertainty, and risks. Clinically meaningful endpoints should be predefined and used to guide continuation, modification, or cessation of therapy.[15,22] Centers should prospectively document treatment indications, timing, clinical responses, complications, resource utilization, and affordability. Such data can support local quality improvement and generate evidence directly relevant to emerging healthcare settings. This context-sensitive implementation pathway is summarized in Figure 1.

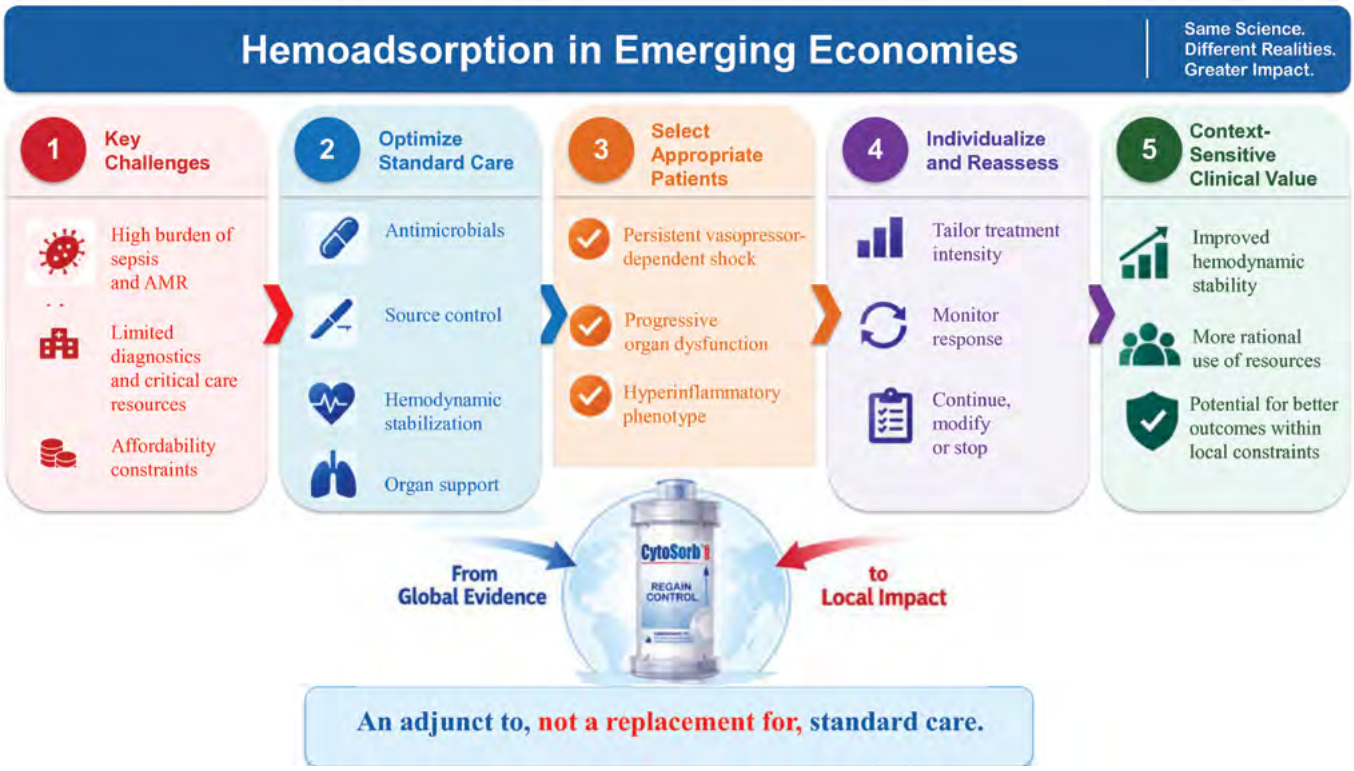


Figure 1. Hemoadsorption in emerging economies.

CONCLUSIONS

Hemoadsorption may serve as an adjunctive therapy in carefully selected patients with persistent shock or progressive organ dysfunction despite optimized standard care. In emerging economies, its use should be guided not only by biological plausibility but also by clinical context, feasibility, and affordability.

A pragmatic approach should emphasize appropriate patient selection, timely initiation, clear treatment goals, feasible monitoring, serial reassessment, and transparent communication with families. Future research should define who benefits most, optimal timing and intensity, and the clinical and economic value of hemoadsorption in resource-constrained settings. The goal should be smarter and context-appropriate use, not wider use.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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USE OF AI

Artificial intelligence tools were used for assistance during the conceptual development of Figure 1. The final figure was created and reviewed by the authors.

AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript, participated in reviewing and editing the manuscript, and approved the final version. The corresponding author takes responsibility for the overall manuscript and its final approval.

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