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Reclaiming the Cardiovascular Physical Examination in the AI Era: Why Bedside Context Still Truly Matters

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Abstract

Background: Artificial intelligence (AI)–enabled decision-support tools are increasingly embedded in cardiovascular care, improving access to guidelines, diagnostics, and risk stratification. However, growing reliance on algorithm-supported workflows may unintentionally de-emphasize bedside clinical skills, particularly the cardiovascular physical examination, at a time when patient context remains central to safe and effective decision making.

Main text: This narrative Perspective reviews historical foundations and contemporary evidence supporting the diagnostic, prognostic, and outcome-related value of cardiovascular physical examination, with particular focus on heart failure and valvular heart disease. We discuss how bedside findings influence risk stratification, therapeutic decisions, and timing of intervention, and examine the limitations of AI-driven tools in capturing social, environmental, and hemodynamic context. We propose an "augmented bedside" model in which AI functions as clinical decision support, while physicians retain responsibility as context-aware managers integrating physical examination, patient goals, and real-world constraints.

Conclusions: In the AI era, cardiovascular care should not move away from the bedside but return to it with enhanced tools. Re-centering practice on a clinically responsible, context-aware physical examination-augmented rather than replaced by AI-offers a practical pathway to improve diagnostic precision and patient outcomes.

Background

Cardiovascular medicine is undergoing rapid transformation driven by evolving evidence-based guidelines and the widespread adoption of artificial intelligence–enabled decision-support tools [1, 2]. These advances have improved efficiency, standardization, and access to care. At the same time, they have reshaped clinical workflows, often prioritizing data streams, automated interpretations, and imaging early in the diagnostic process.

An unintended consequence of this shift is the gradual de-emphasis of bedside clinical skills, particularly the cardiovascular physical examination. When clinical decisions are increasingly mediated through tools, the synthesis of patient context-symptoms, environment, behavior, and goals-may become fragmented [3]. This raises an important question for contemporary practice: what role should the cardiovascular physical examination play in an era of ubiquitous AI decision support?

Historical perspective on cardiovascular physical examination

The cardiovascular physical examination is one of the oldest diagnostic practices in medicine. William Harvey's description of the circulation established the physiological basis for linking cardiac motion to peripheral pulse findings [4]. Leopold Auenbrugger's introduction of thoracic percussion and René Laennec's invention of the stethoscope further formalized bedside assessment of cardiac structure and function [5-7].

For more than a century, auscultation, assessment of jugular venous pressure, and pulse characterization served as primary tools for diagnosing heart failure, valvular disease, and hemodynamic disorders. Even after the introduction of electrocardiography and cardiac imaging, physical examination remained essential for framing differential diagnoses, estimating pre-test probability, and guiding downstream testing [3, 8].Rather than being displaced by technology, bedside examination evolved into a tool for clinical integration and accountability.

Diagnostic and prognostic value of physical examination

Contemporary evidence demonstrates that cardiovascular physical examination continues to provide clinically meaningful diagnostic and prognostic information. In chronic heart failure, findings such as elevated jugular venous pressure, pulmonary congestion, and peripheral edema are independently associated with mortality, hospitalization, and disease progression [9, 10].

Physical examination offers a rapid, non-invasive assessment of hemodynamic status that complements laboratory testing and imaging [10, 11]. Importantly, these findings are observable, reproducible, and immediately actionable at the bedside, reinforcing their relevance in routine clinical practice.

Valvular heart disease and bedside decision making

Valvular heart disease remains a clinical domain in which physical examination can meaningfully influence care pathways. Systematic reviews and population-based studies show that cardiac auscultation can identify clinically significant valvular disease, In conditions such as aortic stenosis, specific bedside signs are associated with at least moderate disease and can inform the urgency of echocardiographic referral [14]. When used appropriately, auscultation functions as a clinical gatekeeper, helping prioritize diagnostic testing and reduce delays in intervention.

Physical examination and patient outcomes

Beyond diagnosis, cardiovascular physical examination influences patient outcomes. Post hoc analyses of major heart failure trials, including SOLVD, demonstrate that bedside findings provide prognostic information comparable to selected biomarkers and support effective risk stratification [9].
Congestion identified on physical examination is not merely a marker of disease severity but a modifiable treatment target. Failure to recognize or adequately respond to congestion contributes to recurrent hospitalization and adverse prognosis [15]. Responsibility for acting on these findings ultimately rests with the treating clinician.
Similarly, delayed recognition of valvular disease due to missed or misinterpreted physical findings is associated with delayed intervention and worse long-term outcomes [13, 14, 16].

Role and limitations of AI in cardiovascular care

AI-enabled decision-support tools have expanded access to guidelines and improved synthesis of complex data, including electrocardiography, imaging, and wearable-derived metrics [1, 2]. These tools enhance efficiency and pattern recognition but remain limited by the quality and completeness of their inputs.
In real-world cardiovascular care, missing data are systematic rather than random. Symptoms may be under-reported, adherence shaped by social and environmental constraints, and patient priorities inadequately captured [17]. Physical examination, combined with social intelligence, provides contextual information that structured datasets often fail to represent.
Ethical considerations-including accountability, bias, and transparency-underscore that AI cannot assume responsibility for clinical decisions. While AI may inform recommendations, clinicians remain responsible for interpreting findings and integrating them into patient-centered care [18, 19] [Figure 1].

The augmented bedside model

We propose an "augmented bedside" model for cardiovascular practice in the AI era. In this framework, AI functions as a clinical copilot that supports evidence retrieval and data synthesis. Clinicians act as context-aware managers who integrate physical examination findings, patient goals, and environmental realities.
Hypothesis-driven physical examination defines pre-test probability and guides appropriate testing. Selective technological augmentation, such as digital auscultation and AI-assisted murmur detection, enhances rather than replaces bedside skills [16, 20]. Closed-loop learning reconciles examination findings with downstream test results, reinforcing clinical calibration and accountability.

Implications for training and practice

Variability in bedside examination performance should prompt improved training rather than abandonment of the skill. Structured curricula, feedback, and deliberate practice remain essential [21, 22]. In the digital era, education should focus on integrating AI tools with bedside reasoning, supporting the development of clinicians who are both technologically fluent and clinically grounded [20].

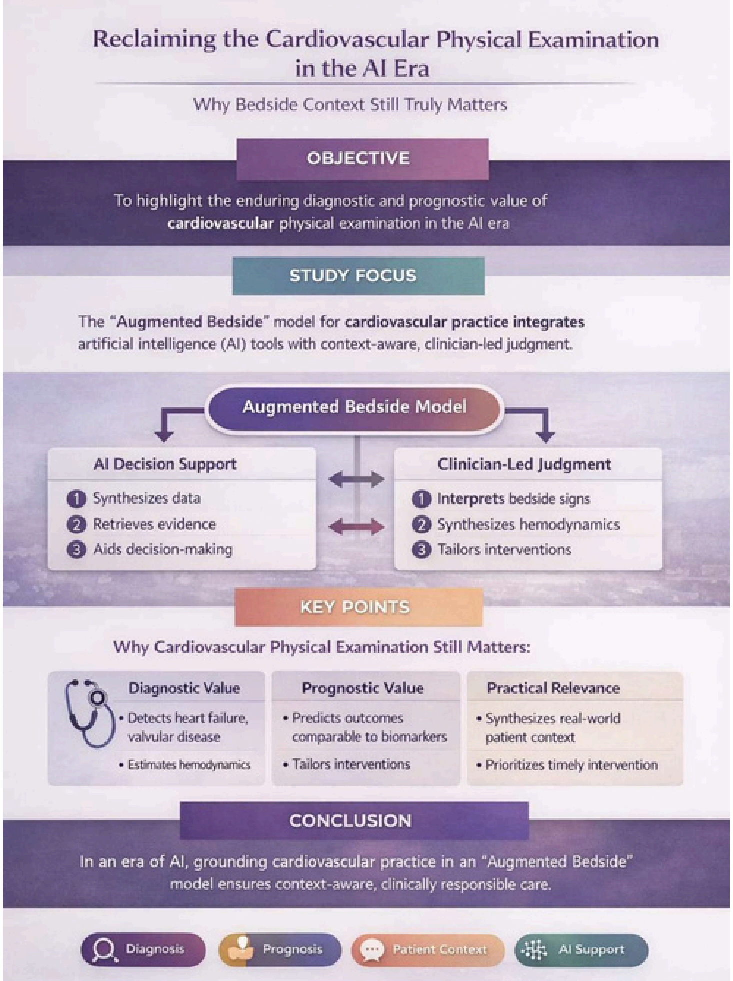

Figure 1: Augmented bedside model for cardiovascular practice in the AI era.

Conclusions

Cardiovascular medicine is not entering a post-clinical era but a period in which clinical meaning must be extracted from abundant tools and incomplete data. Artificial intelligence can enhance access to evidence and support pattern recognition, but it cannot replace bedside judgment or assume responsibility for patient care. Re-centering cardiovascular practice on an augmented bedside model affirms the enduring value of physical examination and the clinician's central role in delivering context-aware, responsible care.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable

Authors' Contributions

Alireza Arzhangzadeh: Investigation; conceptualization; writing–original draft; supervision.

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Competing interests

The author declares that he has no competing interests.

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