Journal of Advances in Medicine and Medical Research

Volume 36, Issue 11, Page 208-214, 2024; Article no.JAMMR.125576
ISSN: 2456-8899, NLM ID: 101711724
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Detection of Hemodynamic Events during the Implementation of a Novel Indigenous Tele ICU System-An Observational Study

Dharanindra Moturu [a++*], Ramesh Babu Potineni [a#], Supriya Rayana [b†], Shaik Jahangir [a‡], Stella [a^], Kavya Sruthi Grandhi [c##] and Mohammad Noor Shaik [c##]

[a] Aster Ramesh Hospital, Vijayawada, Andhra Pradesh, India.
[b] Department of Pharmacy Practice, KL College of Pharmacy, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India.
[c] KL College of Pharmacy, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors DM, RBP and SR designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors DM and SR managed the analyses of the study. Authors KSG and MNS managed the literature searches. Authors SJ and Stella designing an indigenous Tele ICU. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jammr/2024/v36i115631

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/125576

Original Research Article

Received: 23/08/2024
Accepted: 26/10/2024
Published: 02/11/2024

[++] MD, DM Critical Care Medicine, Consultant Critical Care Physician and in charge of Medical ICU;
[#] MD DM Cardiology, HOD Cardiology and Managing Director;
[†] Pharm D, Assistant Professor;
[‡] IT head;
[^] B.Sc. Nursing, Tele ICU in-charge nurse;
[##] Doctor of Pharmacy Program;
**Corresponding author: E-mail: newgenmedico@outlook.com;*

Cite as: *Moturu, Dharanindra, Ramesh Babu Potineni, Supriya Rayana, Shaik Jahangir, Stella, Kavya Sruthi Grandhi, and Mohammad Noor Shaik. 2024. "Detection of Hemodynamic Events During the Implementation of a Novel Indigenous Tele ICU System-An Observational Study". Journal of Advances in Medicine and Medical Research 36 (11):208-14. https://doi.org/10.9734/jammr/2024/v36i115631.*

ABSTRACT

Aim: To assess the incidence of hemodynamic events and their outcomes detected by remote monitoring of hospitalized patients during the implementation of a novel indigenous Tele-ICU system.

Study Design: Prospective observational study.

Place and Duration of Study: Department of Critical Care Medicine, Tele-ICU at Aster Ramesh Hospitals, Vijayawada, between 01-10- 2023 to 01-11- 2023.

Methodology: This observational study was conducted by monitoring 11 ICU units in 9 hospitals, of which 3 were tertiary care and 6 peripheral care centers, remotely using the hub and spoke method by intensivists from the Tele-ICU hub. The study included 209 patients in Intensive Care Units (ICUs) and high dependency units (HDUs) admitted for various critical illnesses. Hemodynamic events like bradyarrhythmia, tachyarrhythmias- supra ventricular arrhythmias, and ventricular arrhythmias were noted. The tele-ICU hub contained audio-visual equipment with central monitoring software (CMS) which permitted monitoring of patient vitals and audio-visual feed from bedside. All the data were observed and inferred. The data was subject to descriptive analysis using cross-tabulation in IBM SPSS Statistics, Version 29.

Results: A total of 314 events were detected and reported for immediate management. The most commonly observed event was Tachycardia (30.56%) followed by Bradycardia (19.42%), Hypoxia (12.73%), non-sustained ventricular tachycardia (7.64%), and Sinus tachycardia (7%). Life-threatening events like Ventricular tachycardia (VT) and Ventricular fibrillation (VF) occurred in 9.3 % (n = 19) and 0.98% (n = 2) cases respectively. Among these cases with life-threatening rhythms (VF, VT) 19 cases were revived and 2 cases couldn't be revived. The overall mortality rate was 6.9 % (n = 14) of which 64.3 % (n = 9) cases were due to bradycardia and 35.7 % (n = 5) cases each of Ventricular fibrillation, Ventricular tachycardia, Tachycardia, Sinus Tachycardia and Sinus Bradycardia.

Conclusion: If designed and implemented effectively, the Indigenous tele ICU system has the potential to be an effective tool for the detection of life-threatening hemodynamic events and thereby help reduce in-hospital cardiac arrest (IHCA) in tertiary and peripheral hospitals**.**

Keywords: Hemodynamic events; indigenous technology; remote monitoring; tele intensive care unit.

ABBREVIATIONS

ICU : Intensive Care Unit
HDU : High Dependency Unit
TELE ICU : Tele Intensive Care Unit
CMS : Central Monitoring Software
LOS : Length of Stay
VT : Ventricular Tachycardia
VF : Ventricular Fibrillation

1. INTRODUCTION

A tele-intensive care unit is a system that leverages telemedicine technology to provide critical care services remotely. It connects specialized intensivists and healthcare professionals to patients in ICUs through advanced communication tools, enabling real-time monitoring and intervention. Key Components are (i) Remote Monitoring: Patients are continuously monitored using advanced devices that transmit vital signs and data to specialists. (ii) Expertise Access: Smaller or rural hospitals can access specialized care without having on-site intensivists. (iii) Data Analytics: Utilizes algorithms and AI to analyze patient data, predicting deterioration and improving decision-making. (iv) Collaboration Tools: Enables real-time communication among healthcare teams, facilitating quick responses to patient needs. Benefits of tele ICU are Improved Outcomes: Enhanced monitoring leads to early detection of complications. Resource Optimization: Efficient use of staff and resources in hospitals with limited personnel [1]. Cost-Effectiveness: Reduces the need for patient transfers to larger facilities. A few challenges are there like Technology Dependence: Requires reliable internet and technology infrastructure. Training Needs: Healthcare staff need training to use tele-ICU systems effectively. Regulatory Issues: Compliance with healthcare regulations and privacy concerns. Tele-ICU represents a significant advancement in critical care, improving access and outcomes for patients in various settings [2,3].

There is a shortage of intensivists, which has led to the increased use of telemedicine technology, allowing intensivists to remotely and simultaneously care for patients in multiple ICUs

(Tele-ICU). This will enable intensivists to manage a greater number of patients at once. Studies have shown that intensivist care in ICU patients reduces morbidity and mortality [4]. Telemedicine Intensive care (Tele-ICU) is defined as "A system in which intensivists and other critical care professionals provide care to offsite patients admitted in remote locations using a network of real-time audiovisual communication and data systems" [5]. It operates like a bedside team, requiring full access to patients' data. Tele-ICU enables real-time monitoring of patient instability and abnormalities, facilitates ordering diagnostic tests, and assists in making diagnosis, prescribing treatment and controlling life support devices [6]. Tele-ICU offers clinical supervision and support, potentially improving patients' health outcomes and reducing overall healthcare costs [5].

Several systematic reviews and observational studies have concluded that Tele-ICU Implementation was associated with an overall reduction in ICU mortality [7-10]. Patients admitted to the ICU often experience organ failure which may involve single or multiple organs. Hemodynamic instability, causing a mismatch between oxygen delivery and demand, is a significant contributing factor for organ failure and may eventually cause death [11]. Additionally, conditions such as Bradycardia, hypoxia, non-sustained ventricular tachycardia, and sinus tachycardia are common complications that can further exacerbate a patient's condition in the ICU. We aimed to evaluate the incidence of hemodynamic events, and their outcomes managed by remote monitoring by implementing a novel Indigenous Tele-ICU system and to analyze the efficiency and performance of an indigenously built tele ICU by locally available hardware and software solutions rather than acquiring proprietary designed and patented systems.

2. MATERIALS AND METHODS

2.1 Study Design and Study Site

This prospective observational study was conducted in the Department of Critical Care Medicine, Tele-ICU at Aster Ramesh Hospitals, Vijayawada. The study received approval from the institutional ethics committee.

2.2 Sample Size and Study Duration

The study involved 209 critically ill patients This observational study was conducted for a period of 1 month by monitoring 11 ICU units in 9 hospitals, of which 3 being tertiary care and 6 peripheral care centers, remotely using the hub and spoke method by intensivists from the Tele-ICU hub, an annex of the Department of Critical Care Medicine at Aster Ramesh Hospitals, Vijayawada.

2.3 Monitoring Protocol

The tele ICU that is being developed is completely Indigenous made of locally sourced hardware and software which enables monitoring of the patient remotely in acute care areas of the hospital. Commonly tele ICU systems are bought in total from patented companies which costs a premium and cannot be afforded by hospitals in Low and middle-income countries.

Patients admitted to the ICUs of tertiary care hospitals and rural ICUs of peripheral hospitals have been monitored using audiovisual hardware installed at the bedside of the patient and connected to the Tele-ICU with the help of a high-speed internet connection and central monitoring software (CMS). The patient's vital parameters like pulse rate, blood pressure, oxygen saturation (SpO_2), and ECG rhythm along with audiovisual feed from the patient's bedside were visible. The Tele-ICU was monitored by qualified intensivists and trained nursing staff who provided point-of-care alerts of hemodynamic events through a dual-way audio connection.

2.4 Statistical Analysis

The data collection was carried out using predesigned Google Forms. A thorough error check was done. The data was subject to descriptive analysis using cross-tabulation in IBM SPSS Statistics, Version 29.

3. RESULTS AND DISCUSSION

3.1 Results

A total of 209 patients were monitored and analyzed in the study period, of these 58.3% were males and 41.6% were females. The median age was 54 years. A total of 314 events were detected and reported for immediate management. The most observed event was tachycardia (30.56%) followed by bradycardia (19.42%), hypoxia (12.73%), non-sustained ventricular tachycardia (7.64%), and sinus tachycardia (7%). Life-threatening events like

ventricular tachycardia (VT) and ventricular fibrillation (VF) occurred in 9.3 % (n = 19) and 0.98% (n = 2) cases respectively. Among these cases with life-threatening rhythms (VF, VT) 19 cases were revived and 2 cases couldn't be revived. The overall mortality rate was 6.9 % (n = 14) of which 64.3 % (n = 9) cases were due to bradycardia and 35.7 % (n = 5) cases each of ventricular fibrillation, ventricular tachycardia, tachycardia, sinus tachycardia and sinus bradycardia. The intensivists at the tele-ICU hub detected these events and alerted the bedside doctor or nurse. The intensivists provided instructions for immediate management to stabilize the patient.

3.2 Discussion

Tele-ICU intensivists provide real-time services to multiple care centers regardless of their location. Tele-ICU has an off-site command center in which a critical care team (intensivists and critical care nurses) monitors patients in distance intensive care units (ICUs) through real-time audio, visual, and electronic means, and health information is exchanged. Studies have shown that hospitals with intensivists on staff had a significant reduction in ICU mortality and average length of stay (LOS) [12]. However, all hospitals might not be able to employ intensivists because of various reasons like availability and affordability [13]. Tele-ICU can provide real-time monitoring of patient instability or any abnormality in the laboratory, ordering diagnostics tests, making diagnosis and ordering treatment, and implementing any intervention through controlling life support devices. As a result, tele-ICU holds great promise in improving the care of critically ill patients [6,14].

In-hospital cardiac arrest (IHCA) is defined in the Utstein Resuscitation Registry reporting template as the delivery of chest compressions and/or defibrillation to patients admitted to inpatient beds. In-hospital cardiac arrest is associated with a high risk of death, but mortality rates are decreasing [15]. In-hospital cardiac arrest has increasingly been recognized as fundamentally different from out-of-hospital cardiac arrest (OHCA) and is increasingly studied independently from the latter. Consequently, our understanding of IHCA and approach to in-hospital resuscitation continues to evolve [16]. American Heart Association (AHA) also advocates early detection of abnormal hemodynamics to prevent IHCA [17].

Ventricular fibrillation (VF) and ventricular tachycardia (VT) are some of the most common rhythms that can be detected before in-hospital cardiac arrest [18]. In our study, we can detect such events. leading to the successful resuscitation of 19 cases.

Hypoxia, or a deficiency of oxygen in the tissues, is a significant contributor to in-hospital cardiac arrest [19]. When oxygen delivery to the body's tissues is inadequate, it can lead to critical complications, including Myocardial Ischemia: Insufficient oxygen supply can impair heart function, leading to arrhythmias or myocardial infarction. Other causes of hypoxia include chronic obstructive pulmonary disease (COPD), pneumonia, or severe asthma, Obstructive Events: Airway obstructions, such as choking or aspiration, can rapidly lead to hypoxia. Pulmonary Embolism: A blockage in the pulmonary arteries can severely reduce oxygenation. Severe Anemia: Low hemoglobin levels reduce the blood's oxygen-carrying capacity [20,21].

Hypoxia is one of the leading causes of cardiac arrest in hospitals, as per the systematic review and meta-analysis by Joseph Allencherril et al. [22] In our study, 12.73 per cent of alerts were due to hypoxemia and were corrected after an alert from the Tele ICU.

Prompt recognition and intervention to restore oxygenation are critical in preventing cardiac arrest related to hypoxia. This may include airway management, supplemental oxygen, and addressing underlying conditions [23]. Eric J et al conducted a study examining the impact of remote monitoring of ICU patients (Tele-ICU) on outcomes such as mortality, complications, and length of stay (LOS). [24] Among 655 patients, the observed hospital mortality rate was 12.0% during the preintervention period and 9.9% during the postintervention period, Similarly the observed ICU mortality rate decreased from 9.2% in the preintervention period to 7.8% in the postintervention period [4].

By optimizing the telemedicine application in the ICU, both the mortality rate and length of stay could be reduced. A 15-60% reduction in the mortality rate along with a 30% reduction in the average length of stay was observed in a hospital with intermittent remote consultation in the delivery of health services to critical care patients by Sajeesh Kumar et al. Another study reported a 45% reduction in severity-adjusted

ICU mortality and, a 30% reduction in hospital mortality and length of stay [25] and in Zawada E et al study observed reductions in length of stay of 47% reported for a tertiary community teaching hospital and 35% for 3 supported rural hospitals [26].

The use of artificial intelligence and machine learning can be incorporated into Tele-ICU for detecting dangerous trends in hemodynamic abnormalities and give preemptive alerts to Tele-ICU physicians and bedside physicians thereby preventing In-hospital cardiac arrest [27].

4. CONCLUSION

Tele ICU is going to improve the care of critically ill patients in remote corners of the world where bedside expertise in critical care medicine might not be available. With appropriate placement and training of bedside staff in its usage, it can reduce the morbidity and mortality of patients due to the lack of qualified intensivists. The increasing availability of good quality internet connection, affordable hardware, and software for creating tele ICU services should be harnessed for reducing morbidity and mortality across lower and middle-income countries. Indigenous systems of Tele-ICU can be built at low cost with locally available hardware, software and can be deployed as in the above study to detect in-hospital hemodynamic abnormalities and take preemptive actions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This study was approved by the institutional ethical committee [RHMB032023].

ACKNOWLEDGEMENTS

Mr.Jahangir and the biomedical team of Ramesh Hospital for understanding the clinician and patient needs and designing an indigenous tele ICU with locally available hardware and software.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Serrano LP, Maita KC, Avila FR, Torres-Guzman RA, Garcia JP, Eldaly AS, Haider CR, Felton CL, Paulson MR, Maniaci MJ, Forte AJ. Benefits and challenges of remote patient monitoring as perceived by health care practitioners: A systematic review. Perm J. 2023, Dec 15;27(4):100-111. Epub 2023 Sep 22. PMID: 37735970; PMCID: PMC10730976.
DOI: 10.7812/TPP/23.022.
2. Ramakrishnan N, Tirupakuzhi Vijayaraghavan BK, Venkataraman R. Breaking barriers to reach farther: A call for urgent action on Tele-ICU services. Indian J Crit Care Med. 2020, Jun;24(6):393-397.
DOI: 10.5005/jp-journals-10071-23447.
PMID: 32863629; PMCID: PMC7435096.
3. Hadian M, Jelodar ZK, Khanbebin MJ, Atafimanesh P, Asiabar AS, Dehagani SMH. Challenges of implementing telemedicine technology: A systematized review. Int J Prev Med. 2024, Feb 29;15: 8.
DOI: 10.4103/ijpvm.ijpvm_48_23.
PMID: 38563036; PMCID: PMC10982727.
4. Thomas EJ, Lucke JF, Wueste L, Weavind L, Patel B. Association of telemedicine for remote monitoring of intensive care patients with mortality, complications, and length of stay. JAMA. 2009;302(24):2671-78.
5. Yoo BK, Kim M, Sasaki T, Melnikow J, Marcin JP. Economic evaluation of telemedicine for patients in ICUs. Crit Care Med. 2016;44(2):265-74.
6. Kumar S, Merchant S, Reynolds R. Tele-ICU: Efficacy and cost-effectiveness approach of remotely managing the critical care. Open Med Inform J. 2013;7: 24-9.
7. Fusaro, Mario V MD, Becker Christian MD. Evaluating Tele-ICU implementation based on observed and predicted ICU mortality: A systematic review and meta-analysis. Critical Care Medicine. 2019;47(4):501-7.

8. Watanabe T, Ohsugi K, Suminaga Y, Somei M, Kikuyama K, Mori M, Maruo H, Kono N, Kotani T. An evaluation of the impact of the implementation of the Tele-ICU: A retrospective observational study. J Intensive Care. 2023;11(1):9.
9. Rosenfeld BA, Dorman T, Breslow MJ. Intensive care unit telemedicine: Alternate paradigm for providing continuous intensive care. Crit Care Med. 2000; 28(12):3925-31.
10. Kalvelage, Christina, Rademacher, Susanne, Dohmen, Sandra, Marx, Gernot, Benstoem Carina. Decision-making authority during Tele-ICU care reduces mortality and length of stay—A systematic review and meta-analysis. Critical Care Medicine. 2021;49(7):1169-81.
11. Huygh J, Peeters Y, Bernards J, Malbrain ML. Hemodynamic monitoring in the critically ill: An overview of current cardiac output monitoring methods. F1000Res. 2016;5:F1000. Faculty Rev-2855.
12. Abraham Joanna et al. Expanding critical care delivery beyond the intensive care unit: Determining the design and implementation needs for a tele-critical care consultation service. Applied Clinical Informatics. 2015;01(2024):178-191.
13. Mosadeghrad AM. Factors affecting medical service quality. Iran J Public Health. 2014, Feb;43(2):210-20. PMID: 26060745; PMCID: PMC4450689.
14. Rangappa Pradeep, Rao Karthik, Chandra Thrilok, Karanth Sunil, Chacko Jose. Tele-medicine, tele-rounds, and tele-intensive care unit in the COVID-19 pandemic. Indian Journal of Medical Specialities. 2021, Jan–Mar;12(1):4-10.
DOI: 10.4103/injms.injms_100_20
15. Andersson Axel et al. In-hospital versus out-of-hospital cardiac arrest: Characteristics and outcomes in patients admitted to intensive care after return of spontaneous circulation. Resuscitation. 2022;176:1-8.
16. Penketh J, Nolan JP. In-hospital cardiac arrest: the state of the art. Crit Care. 2022, Dec 6;26(1):376.
DOI: 10.1186/s13054-022-04247-y.
PMID: 36474215; PMCID: PMC9724368.
17. Nallamothu, Brahmajee K et al. Ten steps toward improving in-hospital cardiac arrest quality of care and outcomes. Circulation: Cardiovascular Quality and Outcomes. 2023;16(11):e010491.
18. Ludhwani D, Goyal A, Jagtap M. Ventricular Fibrillation. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 Jan.
Available:https://www.ncbi.nlm.nih.gov/books/NBK537120/
19. Andersen LW, Holmberg MJ, Berg KM, Donnino MW, Granfeldt A. In-Hospital cardiac arrest: A review. JAMA. 2019, Mar 26;321(12):1200-1210.
DOI: 10.1001/jama.2019.1696.
PMID: 30912843; PMCID: PMC6482460.
20. Allencherril J, Lee PYK, Khan K, Loya A, Pally A. Etiologies of In-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2022, Jun;175:88-95.
DOI: 10.1016/j.resuscitation.2022.03.005. Epub 2022 Mar 10. PMID: 35278525.
21. Boyette LC, Manna B. Physiology, Myocardial Oxygen Demand. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 Jan.
Available:https://www.ncbi.nlm.nih.gov/books/NBK499897/
22. Allencherril J, Lee PYK, Khan K, Loya A, Pally A. Etiologies of In-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2022, Jun;175:88-95.
DOI: 10.1016/j.resuscitation.2022.03.005. Epub 2022 Mar 10. PMID: 35278525.
23. Thomas A, van Diepen S, Beekman R, Sinha SS, Brusca SB, Alviar CL, Jentzer J et al. Oxygen supplementation and hyperoxia in critically Ill cardiac patients: From pathophysiology to clinical practice. JACC Adv. 2022, Aug;1(3): 100065.
DOI: 10.1016/j.jacadv.2022.100065. Epub 2022 Aug 26. PMID: 36238193; PMCID: PMC9555075.
24. Thomas EJ, Lucke JF, Wueste L, Weavind L, Patel B. Association of telemedicine for remote monitoring of intensive care patients with mortality, complications, and length of stay. JAMA. 2009, Dec 23;302(24):2671-8. PMID: 20040555.
DOI: 10.1001/jama.2009.1902.
25. Rosenfeld BA, Dorman T, Breslow MJ et al. Intensive care unit telemedicine: Alternate paradigm for providing continuous intensivist care. Crit Care Med. 2000;28(12):3925-3931.
26. Zawada E, Herr P, Erickson D, Hitt J. Financial benefit of a teleintensivist

program to a rural health system. Chest. 2007;132(4):444

27. Lu Y, Wu H, Qi S et al. Artificial intelligence in intensive care medicine: Toward a ChatGPT/GPT-4 way?. Ann Biomed Eng. 2023;51:1898–1903. Available:https://doi.org/10.1007/s10439-023-03234-w

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/125576