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Remote Monitoring, AI, Machine Learning and Mobile Ultrasound Integration upon 5G Internet in the Prehospital Care to Support the Golden Hour Principle and Optimize Outcomes in Severe Trauma and Emergency Surgery

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Abstract. Aim: Feasibility and reliability evaluation of 5G internet networks (5G IN) upon Artificial Intelligence (AI)/Machine Learning (ML), of telemonitoring and mobile ultrasound (m u/s) in an ambulance car (AC)- integrated in the pre-hospital setting (PS)- to support the Golden Hour Principle (GHP) and optimize outcomes in severe trauma (TRS). Material and Methods: (PS) organization and care upon (5G IN) high bandwidths (10 GB/s) mobile tele-communication (mTC) experimentation by using the experimental Cobot PROMETHEUS III, pn:100016 by simulation upon six severe trauma clinical cases by ten (N1=10) experts: Four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2) to evaluate feasibility, reliability and clinical usability for instant risk, prognosis and triage computation, decision support and treatment planning by (AI)/(ML) computations in (PS) of (TRS) as well as by performing (PS) (m u/s). Results: A. Trauma severity scales instant computations by the Cobot PROMETHEUS III, pn 100016)) based on AI and ML complex algorithms and Cloud Computing, telemonitoring and r showed very high feasibility and reliability upon (5GIN) under specific, technological, training and ergonomic prerequisites B. Measured be-directional (m u/s) images data sharing between (AC) and (ED/TC) showed very high feasibility and reliability upon (5G IN) under specific, technological and ergonomic conditions in (TRS). Conclusion: Integration of (PS) tele-monitoring with (AI)/(ML) and (PS) (m u/s) upon (5GIN) via the Cobot PROMETHEUS III, (pn 100016) in severe (TRS/ES), seems feasible and under specific prerequisites reliable to support the (GHP) and optimize outcomes in adult and pediatric (TRS/ES).

Keywords. Prehospital Trauma Organization and Care, Artificial Intelligence/ Machine Learning in Health Care, Golden Hour, 5G Internet Networks, Prehospital Mobile Ultrasound.

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1. Introduction

Feasibility and reliability evaluation of 5G internet networks (5G IN) upon Artificial Intelligence (AI)/Machine Learning (ML) and mobile ultrasound (m u/s) in an ambulance car (AC)- integrated in the pre-hospital setting (PS)- for tele-diagnosis, severity classification, triage computation, prognostication and treatment planning to support the Golden Hour Principle (GHP) and optimize outcomes in Trauma (TRS) and Emergency Surgery (ES) [1-5].

2. Material and Methods

(PS) organization and care upon (5G IN) high bandwidths (10 GB/s) mobile tele-communication (mTC) experimentation by using the Cobot PROMETHEUS III, pn:100016 by simulation upon six (N=6) severe trauma clinical cases by ten (N1=10) experts- four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2)- to evaluate feasibility, reliability and clinical usability. Experimentation included the development of an experimental Cobot PROMETHEUS III, (pn:100016) for the simulation of the integrated remote AI, Machine Learning and Mobile Ultrasound upon 5G Internet prehospital care [3,4] (Table 1.).

Table 1. The Basic Modules of Cobot PROMETHEUS III, (pn:100016).

Modules	Exp. Cobot PROMETHEUS III, pn:100016
a. Medical record process	+
b. Examinations results.	+
c. Capture scanning and imaging.	4K
d. DICOM and PACS vision.	+
e.Real-time tele-conference	+
f. Application sharing.	+
g. Tele-monitoring facilities (ECG, SatO2, BP,T, Respiration)	+
h. Tele-Mentoring facilities	+
i. Telecommunication net	5G Internet based
j. Multimedia System	+
k.AI computation system	+

The simulating use of the Cobot PROMETHEUS III, (pn:100016) by the rescuers of the Ambulatory emergency care unit (AECU=EKAB in Hellenics) of Thessalia Periphery in Hellas, upon an experimental doll, focused on the remote instant risk, prognosis and triage computation, tele-monitoring, decision support and treatment planning by (AI)/(ML) computations in (PS) of (TRS) as well as on performing (PS) (m u/s) (Mindray DP-18 DUDS) in an (AC) to evaluate its feasibility, reliability and clinical usability to support the Golden Hour Principle (GHP) and optimize outcomes in (TRS), and took place from the Aretaieion University Hospital and the Attikon University Hospital of Athens on 19.05.2022, from the City of Volos on 27.07.2022 and the War Museum of Athens on 24.06.2023 and on 26.06.2023 [4] and from the Joist Innovation Park of Larisa in Thessalia and the Hippokrateion University Hospital of Athens and the Attikon University Hospital of Athens on 29.02.2024 [5,6] (Figure 1).

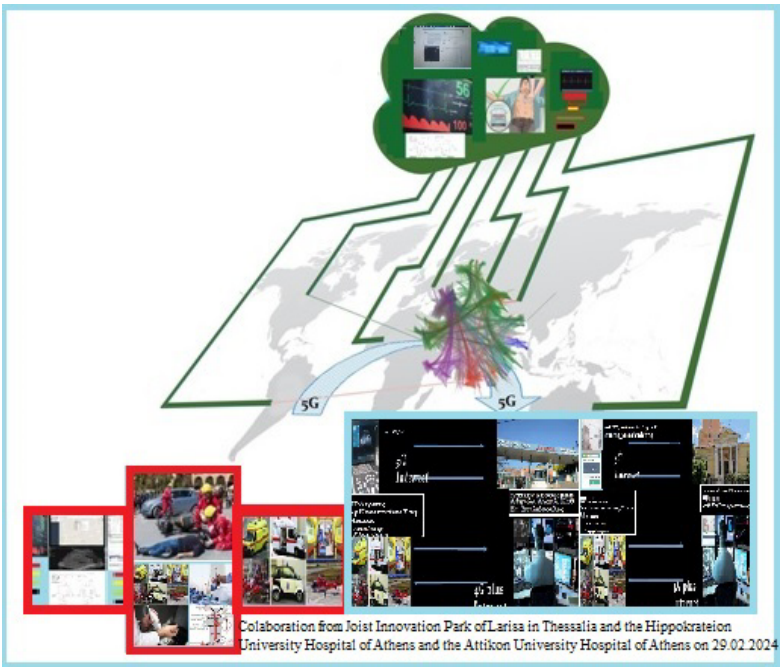

Figure 1. Simulation of the remote collaboration upon six (N=6) severe trauma clinical cases by ten (N1=10) experts: Four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2) to evaluate feasibility, reliability and clinical usability for instant risk, prognosis and triage computation, tele-monitoring, decision support and treatment planning by (AI)/(ML) in the Aretaieion University Hospital of Athens on 19.05.2022, from the Aretaieion University Hospital and the Attikon University Hospital of Athens on 19.05.2022, from the City of Volos on 27.07.2022 and the War Museum of Athens on 24.06.2023 and on 26.06.2023 and from the Joist Innovation Park of Larisa in Thessalia and the Hippokrateion University Hospital of Athens (Professor of Trauma Surgery S.Stergiopoulos and the Attikon University Hospital of Athens (Professors of radiology N.Kelekis and S.Speliopoulos) on 29.02.2024 [1,2,4-7].

3. Results

A. Real time data sharing between rescuers and the patient (R/P) and the Ambulance (A) and Emergency Department/Trauma Center (ED)/(TC) established, combining both 5G-radio and-core network parts. Besides technical performance evaluations, a medical assessment of computations and their latency in the rescue process latency of transmission in be-directional (m u/s) images data sharing between (AC) and (ED/TC) in the prehospital setting evaluated. Trauma severity scales computations by the experimental Cobot PROMETHEUS III, (pn 100016) of the Program of Excellence 2014-16 based on AI and ML complex algorithms and Cloud Computing (i.e. ISS, GCS, TRISS, ASCOT) showed high tele-communication and data sharing feasibility and reliability upon (5GIN) under specific, technological, training and ergonomic conditions. (5G IN) test revealed an average latency of a minute to compute two trauma scales scores by AI in the rescue simulating experimental process [1-5], **B.** Measured be-directional (m u/s) images data sharing between (AC) and (ED/TC) showed high feasibility upon (5G IN) under specific, technological and ergonomic conditions in (TRS). (5G IN) test revealed an average end-to-end round trip latency of 10

milliseconds (<1 ms), however fully qualitative radiological image for reliable remote diagnosis from the (A). This depends on (m u/s) quality, on its digital connection to (mTC) and on their inherent phenomena (LOS, Scattering, Frequency Hopping) in telecommunications and mainly on the level of training by the users (rescuers and expert personnel in the radiology department (RD) of (ED/TC), **C.** The presence of a physician in the rescue team to perform life saving interventions (i.e. iv canulation, intubation, tracheostomy, thoracic intubation, hypothermia prevention, hemorrhage control by hemorrhage dressings and tourniquets, REBOA in ED, etc.), is more essential (Tables 2, 3, 4) [4,5,8].

Table 2. Simulating remote instant risk, prognosis and triage computation, tele-monitoring, decision support and treatment planning by (AI)/(ML) computations in (PS) of (TRS) upon six cases.

N	N1	n1	n2	n3	n4	FEASIBILITY	RELIABILITY	ACCURACY
6	10	4	3	8	**2**	**Very High**	**Very High**	**Very High**

Six (N=6) severe trauma clinical cases, ten (N1=10) experts: Four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2)

Table 3. Simulated (PS) remote monitoring (ECG, SatO2, BP,T, Respiration) of patients suffering from severe trauma in (TRS) tele-diagnosis accuracy and decision making feasibility and reliability in (TRS) upon six cases.

N	N1	n1	n2	n3	n4	FEASIBILITY	RELIABILITY	ACCURACY
6	10	4	3	8	**2**	**Very High**	**Very High**	**Very High**

Six (N=6) severe trauma clinical cases, ten (N1=10) experts: Four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2)

Table 4. Simulating remote (PS) (m u/s) (Mindray DP-18 DUDS) in an (AC) tele-diagnosis accuracy and decision making feasibility and reliability in (TRS) upon two case.

N	N1	n1	n2	n3	n4	FEASIBILITY	RELIABILITY	ACCURACY
6	10	4	3	8	**2**	**Very High**	**Very High**	**Very High**

Six (N=6) severe trauma clinical cases, ten (N1=10) experts: Four professional rescuers (n1=4), three trauma surgeons (n2=3), a radiologist (n3=1) and two information technology specialists (n4=2)

4. Discussion

Artificial intelligence (AI) and machine learning (ML) upon 5G (IN) are at the forefront of digital medicine. They have been extensively applied to various medical domains such as cardiology, ophthalmology, emergency medicine and many others. The adoption of (AI) and (ML) techniques in the (PS) of (ES) /(TS), both structured and unstructured data (e.g., medical images, clinical free texts, time-series physiological signals) benefit from the versatility and flexibility of (AI) and (ML) techniques. In addition to third level healthcare institution-based applications, the intersection of the Internet of Things (IoT) AI and ML have also attracted interest in the form of remote continuous health monitoring [1,2,8,9]. On the other hand, Ultrasound performed in the (PS) and the transference of a patient seems to be accurate and reliable for remote diagnosis and decision making and can improve early treatment and management. The use of the Cobot PROMETHEUS III, (pn 100016) of the Program of Excellence 2014-16 in the (PS) seems feasible and reliable under specific clinical, technological, training and ergonomic prerequisites to support the Golden Hour Principle and optimize patients' outcomes in severe trauma and emergency

surgery [4,5,6,7]. However, the main drawback of our experimental model is that is based on the very high expertise and the deep clinical experience of established clinical and academic professionals in trauma/emergency surgery, in radiology and in medical informatics science. We keep always in mind what a professor of radiology in the Aretaieion University Hospital said after the first experimentation in 2022 that ''it can save a lot of lives''. However, further experimentation with bigger samples of experts and clinical cases and a randomized design of the applied clinical performance, applied technology, techniques, ergonomics and training specifications evaluation has been planned.

5. Conclusion

Integration of (PS) tele-monitoring with (AI)/(ML) and (PS) (m u/s) upon (5GIN) via the Cobot PROMETHEUS III, (pn 100016) of the Program of Excellence 2014-16 in severe (TRS/ES), seems feasible and under conditions reliable for real-time remote complex risk and severity scale computations for remote monitoring, collaborative accurate diagnosis, severity classification, triage, prognostication and decision support and treatment planning to support the (GHP) and optimize outcomes in both adult and pediatric (TRS/ES).

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