

Comparative Investigation of Mobile Portable Complex System Functional and Laboratory Diagnostics with Stationary Equipment

Abai Baigenzhin¹, Lina Zaripova², Elmira Chuvakova³, Larissa Kozina⁴, Turlan Zhumashev⁵

¹Chairman of the Board, National Scientific Medical Center, Astana, Kazakhstan

²Department of Scientific and Innovation Management, National Scientific Medical Center, Astana, Kazakhstan

³Deputy Chairman of the Board in the field of science, National Scientific Medical Center, Astana, Kazakhstan

⁴Central Research Laboratory, National Scientific Medical Center, Astana, Kazakhstan

⁵Reception Department, National Scientific Medical Center, Astana, Kazakhstan

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Corresponding author:

Lina Zaripova.

E-mail: zaripova_lina@list.ru.

ORCID: 0000-0001-8728-0225.

Abstract

The aim of the current study is to evaluate the effectiveness of using mobile portable complex system functional and laboratory diagnostics in patients compared to stationary equipment. The scientific study examined the results of functional and laboratory diagnostics of 123 patients who were at JSC NSMC at the time of diagnosis and treatment. The study covered a 1-year period from January 2023 to December 2023. Patients were divided into two groups: 1 group – 63 patients, who were diagnosed using expert stationary equipment of NNMC; 2 group – 60 patients who were diagnosed using the mobile portable complex Health Examination System HES-7 (Konsung Technology; 2023).

Results: Laboratory diagnostics were performed in 63 (100%) patients of the 1st group and in 60 (100%) patients of 2nd group. The compared groups had the same characteristics, in particular, anaemia was detected in 4 (6.35%) patients of first group and in 5 (8.33%) patients of the second group. Mortality was not observed in the compared groups. According to all data obtained minor differences in diagnostic findings were found (1 to 6%). HES-7 demonstrated quite accurate functional analysis: electrocardiography, pulse oximetry, and spirometry.

Conclusion: The use of the digital mobile complex of functional and laboratory diagnostics Health Examination System HES-7 is safe and can be effectively used in primary health care settings by experienced nursing staff.

Keywords: mobile laboratory and functional diagnostics, health care, research.

Introduction

Functional and laboratory analyses are the basis for diagnosing any disease. The rapid progress of diagnostics and its main successes lie in the digital technological progress of small-sized medical equipment systems, which contributes to the spread of primary diagnosis of patient diseases. This technology makes possible to obtain primary results of diagnosing

patients' diseases in an optimal time frame and allow to define the need of emergency hospitalization.

Objective

The aim of the scientific work is to evaluate the effectiveness of using mobile portable complex system of functional and laboratory diagnostics in medical

care. This study includes a series of diagnostic studies of patients with various diseases at JSC “NNMC” in Astana, the Republic of Kazakhstan.

Materials and methods

We examined the results of diagnostics of 123 patients with diseases: diabetes mellitus, heart rhythm disturbances, angina pectoris, and chronic obstructive pulmonary disease (Table 1), diagnosed in the medical institution of NNMC. The study covered a 1-year period starting January 2023 and ending December 2023. Ethics approval was obtained from Local ethical committee of the National Scientific Medical Center (№085). Helsinki Declaration was followed at all stages of the study.

The patients were divided into two groups. The first group of patients underwent diagnostics on the expert stationary equipment (63 patients). The second group included 60 patients which analysis was taken with the mobile digital complex Health Examination System HES-7 (HES-7, Jiangsu Konsung Bio-medical Science and Technology Co, LTD). The HES-7 provide the digitalization of the entire diagnostic process on site location of the patient and the possibility of providing 21 remote medical services, performing wide range of high-quality primary laboratory and functional diagnostics within 15-30 minutes. The NES-7 complex includes compact laboratory diagnostic devices: blood, urine analysis, biochemical analyser (low- and high-density lipoproteins, total cholesterol, triglycerides, blood glucose, urea, creatinine, uric acid, AST, ALT, and albumin), immunofluorescent analyser for determining the level of C-reactive protein (CRP), procalcitonin (PCT), brain natriuretic hormone (NT-proBNP), glycosylated haemoglobin (HbA1c), Ferritin (Ferritin), Dimer (D-dimer), vitamin D (25- OH vitamin D), troponin/creatinine kinase/myoglobin (cTnI/CK-MB/MYO), thyroid hormone (T3, T4), thyroid-stimulating hormone (TSH), antibodies to Helicobacter (HP-Anti-H.pylori IgG), human chorionic gonadotropin (HCG). Functional diagnostics integrated into the monitor include electrocardiography (ECG), pulse oximeter, tonometer, thermometer, spirometer, electronic stethoscope, foetal Doppler. During the examination of patients, the “one-window” principle was applied to the HES-7 operating algorithm. All diagnostic procedures were carried out by nursing staff and included: electrocardiographic examination, pulse oximetry, thermometry, blood pressure measurement, spirometry, auscultation, biochemical blood test, general blood and urine analysis. All diagnostic procedures were combined by artificial intelligence into a single digital complex; diagnostic data is sent via the Internet to a medical information system; when deviations from the reference norm are determined, the complex signals the medical worker on a digital display the deviation from the health norm with a red indicator arrow. The results are transferred to the medical information system (MIS) DamuMed to the doctor via online for telemedicine consultations “doctor-doctor”, “doctor-nursing worker” for diagnostics, consultation in the process of treatment and rehabilitation by doctors.

Statistical analysis was performed with SPSS 19.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the distribution of continuous variables. Continuous variables obtained from the analysis were reported as means ± standard deviations. Student's t-tests were used to compare normally distributed parameters, while Mann-Whitney U tests were used for non-normally

distributed variables. A significant P-value was considered to be less than 0.05.

Results

Both groups of patients were comparable in age and weight at the time of initial diagnosis, and the number of concomitant anomalies (tab.1, 2). In the first group there were 19 patients with an association of heart rhythm disturbances

Table 1

Comparison of different equipment according to the time of initial diagnosis and hospital stay (1st group – expert stationary equipment; 2nd group – mobile equipment)

Indicator	1 Group (n=63)			2 Group (n=60)			“p” value
	mean	SD	range	mean	SD	range	
Diagnostic duration, min	39,13	3,12	3–70	15,61	3,58	3–18	0.049
Duration of hospital stay, days	10,4	3,54	5–22	9,11	3,16	5–17	0.310

“n” – the number of cases, «Mean» – the average value, «range» – the minimum and maximum value of the parameter, «SD» – the standard deviation.

Table 2

Comparison of patient groups by comorbidity, mortality and complications (1st group – expert stationary equipment; 2nd group – HES-7 compact mobile equipment)

Gender		
Groups	male	female
1 Group (n=63)	25 (39,68%)	38(60,32%)
2 Group (n=60)	23 (38,33%)	37 (61,67%)
Comorbidities		
Groups	abs	exists
1 Group (n=63)	42 (66,67%)	21(33,33%)
2 Group (n=60)	41 (68,33%)	19 (31,67%)
Mortality		
Groups	abs	
1 Group (n=63)	0 (0,0%)	
2 Group (n=60)	0 (0,0%)	
Anemia		
Groups	abs	exists
1 Group (n=63)	59 (93,65%)	4 (6,35%)
2 Group (n=60)	55 (91,67%)	5 (8,33%)
Deviations in leukoformula parameters		
Groups	abs	exists
1 Group (n=63)	58 (92,07%)	5 (7,93%)
2 Group (n=60)	56 (93,33%)	4 (6,67%)
Hyperglycemia		
Groups	abs	exists
1 Group (n=63)	52 (82,54%)	11 (17,46%)
2 Group (n=60)	50 (83,33%)	10 (16,67%)
Pathology of the cardiovascular system		
Groups	abs	exists
1 Group (n=63)	38 (60,32%)	25 (39,68%)
2 Group (n=60)	37 (61,67%)	23 (38,33%)
Respiratory diseases		
Groups	abs	exists
1 Group (n=63)	55 (87,31%)	8 (12,69%)
2 Group (n=60)	55 (91,66%)	5 (8,33%)

and arterial hypertension, 6 patients had angina pectoris and 11 other diseases, such as diabetes mellitus, anaemia, lungs and respiratory pathology. In the second group, 18 patients had cardiac arrhythmia and arterial hypertension, 5 had angina pectoris, 10 had diabetes, 5 had anaemia, whereas diseases of the lungs and respiratory system were recorded in 5 patients. The ratio of patients with primary functional and laboratory diagnostics were equal in the compared groups. Immediate diagnostic results are presented in table 1. A difference was revealed in the duration of primary diagnostics: the average duration of diagnostic examinations were 39.13 minutes (3–70 minutes) in the diagnostic group using stationary expert-class equipment and 16.61 minutes (3–18 minutes) in the diagnostic group using the “Diagnostic System health HES-7” with a significant difference ($p < 0.05$).

There was no discrepancy in diagnostic data and no mortality were observed in the compared groups. Patients from both groups had comparative level of concomitant diseases (in group 1 – 21/63 (33.33%); in group 2 – 19/60 (31.67%).

The analysis of the 30 patients from the 2nd group were double checked with stationary equipment of the laboratory of NSMC. As a result, the difference in complete blood count did not reach the average of 3%; difference in biochemical tests consisted in 5% for creatinine, 3% – for urea, 2% – cholesterol, 2% – high-density and low-density lipoproteins, 1% – triglycerides, 6% for transaminases, 4% for albumin; the difference in urine testing was 5% (Tab. 3). HES-7 demonstrated quite accurate functional examination: electrocardiography, pulse oximetry, and spirometry assessed by comparison with similar hospital equipment.

Table 3

Comparison of patient groups by comorbidity, mortality and complications (1st group – expert stationary equipment; 2nd group – HES-7 compact mobile equipment)

Parameters	Automatic systems with internal and external quality assessment n=30, M±m	Mobile portable complex system n=30 M±m	“p” value
Hemoglobin (g/l)	127,1±3,9	129,5±3,2	0,630
White blood cells (*10 ¹² /l)	5,53±0,16	5,64±0,15	0,841
Red blood cells (*10 ⁹ /l)	4,22±0,18	4,41±0,12	0,151
Creatinine (mmol/l)	64,70±2,16	66,87±2,1	
Urea (mmol/l)	3,74±0,29	3,92±0,31	
LDL (mmol/l)	1,17±0,07	1,23±0,08	
HDL (mmol/l)	0,73±0,04	0,78±0,04	
Triglycerides (mmol/l)	1,24±30,09	1,27±0,10	
ALT (mmol/l)	0,57±0,04	0,61±0,05	
AST (mmol/l)	0,60±0,03	0,64±0,04	
Albumin (g/l)	24,7±1,9	26,0±2,0	
Protein in urine (g/l)	0,03±0,002	0,032±0,002	0.26
Urine pH (mmol/l)	6,0±0,46	6,2±0,47	

Based on the laboratory studies, we can recommend the further use of the HES-7 health diagnostic system to determine the main parameters in small laboratories and primary care places that are not equipped with expensive automatic stations

and closed-type devices (particularly in rural healthcare). The HES-7 complex can be indispensable for providing medical care in emergency situations due to its mobility (small dimensions and weight of the kit within 8.5 kg).

In general, a reduction in the duration of diagnosis was observed when using digital mobile diagnostic technologies; this is quite understandable in terms of the timing of obtaining diagnostic results and the accuracy of the results, which made it possible to ensure earlier hospitalization of the 2nd group compared to the 1st group. The average duration of hospitalization in patients who underwent diagnostic tests on stationary equipment did not differ significantly from the length of hospitalization performed on mobile digital equipment. There was no increase in the duration of hospitalization, nor an increase in the number of complications.

Discussion

At the beginning of the XX century, functional and laboratory diagnostics underwent revolutionary changes. The main goal was to create diagnostic systems using specialized computer equipment [1]. Other opportunities also opened up and were implemented gradually: the creation of an electronic medical archive, the development of mathematical methods for analysing patient examination data, computer modelling of the operation of systems and organs, complex medical information systems integrated with the Internet, electronic accounting of medicines [2].

In this regard, the experience of using computer diagnostic systems in primary health care is noteworthy [3, 4]. A new model of medical care has been introduced, combining teleconsultations, digital solutions and mobile medical teams, which allows the provision of a wide range of health services by a multidisciplinary team of health workers. Since 2019, the Swedish government has implemented new public health policies aimed at promoting programs and continuously monitoring the availability of health care in remote rural areas with telemedicine [5]. The country has shifted the emphasis of medical care from hospitals to primary care and spends relatively little on inpatient care in hospitals, focusing instead on primary health care and long-term care [6]. The largest category of health care spending in Sweden is outpatient care (primary care, including home care), which accounted for just over one-third (34%) of all health care spending last year. This is the result of efforts over the past two decades to contain hospital costs while actively developing primary care [7].

With the development of science and cybernetics, mobile analysers of innovative designs of compact sizes have been evolved, capable of examining several analysis parameters in a short time with low reagent consumption and easy operation.

Investigating new diagnostic system at our hospital, we found accuracy, convenience and ease of use. The advantage of mobile laboratory equipment is the compactness and speed of obtaining diagnostic test results (3-18 minutes), the low cost of reagents compared to stationary expert equipment, the availability of mobile laboratory diagnostics reduces the morbidity and mortality of the population, where stationary diagnostics are not readily available. Because of the use of diagnostic studies using the digital mobile complex “Health Diagnostic System HES-7”, the “one window” principle was applied, allowing in one office, in a short time, to carry out functional and laboratory diagnostics of patients, make a diagnosis, and conduct a teleconsultation with a specialist. When using the mobile complex, primary

functional and laboratory diagnostics are carried out, the function of providing remote medical services is implemented, in which a specialist can provide telemedicine consultations “doctor-patient”, “doctor-nursing staff”, “doctor-doctor” at the level of consultation. Taking into account the possibility of portable diagnostics the system usage have economic benefits by reducing costs for patient way to the conventional laboratory. Doctors and medical professionals express positive feedback regarding the functionality and convenience of HES-7 system. The system is easy to integrate into clinical practice and provide convenient tools for effective diagnosis especially in primary care in remote areas.

The results of our research demonstrate that the use of mobile diagnostics in the treatment of patients is safe, simple and effective. Further improvement of cybernetics devices will make it possible in the nearest future to achieve advanced diagnostic results in shorter time. It will be possible to improve the timing of diagnosis, treatment and hospitalization of patients, placing emphasis on the outpatient health care sector. In mobile diagnostics of diseases, the principle of “one window” is applied to provide primary health care “here and now” in one office; from the point of view of the advantages of functional and laboratory diagnostics, there is no doubt. It is possible to adopt this approach as the “gold standard” in diagnosing diseases of primary health care patients, perhaps in the coming years, by equipping remote primary health care settlements with mobile diagnostics: in outpatient clinics, medical, paramedic and obstetric centers, pre-medical offices, where primary diagnostics would be carried out to provide primary medical care in remote settlements. The uniqueness of the HES-7 system is highlighted by the fact that existing analogues only consider the functional

part of the diagnostic system. However, the laboratory part of a diagnostic system analogue cannot be solved. The parameters of comparability, functional studies of ECG, pulse oximetry and spirometry assessed by comparison HES-7 with similar hospital equipment did not reveal any significant differences that may influence diagnostic results. The portable system meets quality standards and regulatory requirements, confirming its safety and efficacy in diagnostic procedures.

The benefit of this new approach is difficult to assess objectively due to the low prevalence of mobile diagnostics, so this research provides evidence of the benefits of mobile portable complex HES-7 and show a new perspective in primary care. Because minor insignificant differences were observed between the portable device and stationary equipment, it can be concluded that this portable device could be useful in the practice of doctors and other medical professionals especially for diagnostics in remote areas.

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