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Point-of-care Diagnostic Device in Healthcare: A Literature Review

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Abstract – Point-of-care (POC) device is an in-vitro diagnostic device utilized by medical professionals near patients, bedside or extra laboratory testing to obtain results quickly and simply and improve the patient care. POC device alert only the crucial data to clinicians or medical professionals. In addition to patient health monitoring, POC devices can be used for cancer, diabetes, and cardiovascular diseases diagnosis (rule – in or rule – out) and management especially in emergency departments, physician office, paramedicine, and mobile units. This review aims to illustrates the use of POC devices for diabetes and cardiovascular management.

Keywords – Point-of-care; in-vitro diagnostic; cancer; diabetes; cardiovascular disease; emergency.

INTRODUCTION

Health care is the organized provision of diagnose, treatment, prevention and management of diseases or illness and improve the quality of patient. Fast evolving healthcare industry has led to numerous innovations in diagnostic devices to treat patients quickly and accurately to assess and treat more patients in emergency, primary care. Health care is becoming transformative in identifying the onset of disease at an early stage and in some cases health care prevents even before the onset of diseases. One of the best ways to achieve is patient centered and near patient testing for faster triaging and treatment. The Point– of- care (POC) devices also known as near- patient testing typically placed near the patient or bedside and obtain quicker results. As the need for faster test results growing, diagnostic devices like easy to use, portable, miniaturized devices have evolved.

A. Applications of POC:

1) Diabetes Management: Diabetes is a highly prevalent diseases in development of several other diseases are cardiovascular or renal disease. Based on International Diabetes Federation (IDF) Diabetes Atlas, in 2030 diabetes incidence is projected to increase to 552 million [35]. In emergency clinics, hypoglycemia and hyperglycemia are related with higher death and length of stay. Hence, bed-side glucose monitoring with rapid, accurate and high turnaround time (TAT) was in demand. However, central laboratory testing (CLT) is the reference testing of plasma glucose. Various lab tests are prescribed in the detection of patients with diabetes. The initial stated use of POC is observed in early documents from 1550 B.C, in which physicians used ants to measure sugar in the blood [39]. After enormous research, the breakthrough came in 1965 by an Ernie Adams tram develop primary stick, a Dextrostix, stick that used oxidoreductase enzymes. Further followed by advancement in quantitative blood glucose result by Ames team and developed Ames Reflectance meter in 1970 [38].

Immediate results obtained from POC device are crucial in reducing the diagnosis time and initiate the treatment for patients. Some of the POC devices available in the market are tabulated below (Table I).

TABLE I
POC devices in Diabetes Management

POC device	Company	Purpose
Accu-Chek Aviva Plus	Roche	Glucose meter
Accu-Chek Nano	Roche	Glucose Meter
ReliOn Prime	ReliOn	Glucose

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		meter
OneTouch VerioIQ	LifeScan	Glucose Meter
Nova Max	Nova	Glucose meter
FreeStyle Lite	Abbott	Glucose meter
Afinion HbA1C Dx Assay	Abbott	HbA1C testing
HemoCue HbA1c 501 system	HemoCue	HbA1C testing

2) Cardiovascular Diseases:

Cardiovascular diseases are one of the life-threatening and early diagnosing is first and foremost. Cardiac Markers can be effectively used not only for the treatment of cardiovascular diseases but also early diagnosis.

a) *History of Cardiac markers:*

Ladue et al (1954) proposed the first cardiac biomarker aspartate aminotransferase (AST) released from cardiac muscle cells experiencing cell death would be beneficial in identifying severe myocardial infarction (MI) using paper-based chromatography [4]. At present, AST has been ruled-out due to lack of specificity for diagnosing AMI. AST levels elevate in hepatic disease, pulmonary embolism. Wroblewski and Ladue found a change in lactate dehydrogenase (LDH) activity in AMI patients. But Ulmer et al. corroborated this finding. Schmiechen et al (1997)

proposed another crucial biomarker lactate dehydrogenase (LDH) for detecting myocardial ischemia. LDH peaks in 6 to 12 hours after an AMI [6]. It is also specific for non-cardiac diseases like erythrocyte haemolysis and testicular germ cell tumour markers.

Dreyfus et al (1960) proved creatine kinase (CK) activity in the detection of myocardial infarction. Although various studies and experiments observed higher sensitivity of CK during diagnosis of AMI, it highly lacks its specificity as a biomarker [7]. Wroblewski proposed that the measurement of specific isoenzymes (CK-MB) provide a reliable result and increase the specificity of cardiac enzyme biomarkers [8]. Gilkeson et al (1978) developed the earlier method to detect serum myoglobin using radioimmunoassay (RIA) but late discontinued for STAT analysis due to time consuming process [10].

In 1985, mass assays to estimate the protein concentration for CK-MB were developed by Chan et al. [11]. Later in 1986, Vaidya et al, created the first monoclonal antibody to CK-MB and at present all automated immunoassay instrumentation are used [13]. In 1963, after several studies Professor Setsuro Ebashi proved that a new troponin compound is responsible for the muscle regulation [14]. Various studies showed the two mutated human cardiac troponin (cTn) components, cTnI and cTnT are the main cause of cardiomyopathies. In 1987, Cummins established the effective primary RIA for the measurements of cTnI in serum [15]. Over the past 30 years, several research groups continuously optimizing cTnI immunoassay and have analytical sensitivity is almost 100-folder higher than experimental assays that were initially described.

In 1989, Katus et al developed the first-generation immunoassay based on enzyme linked immunosorbent assay (ELISA) with two antibodies [16]. Cross reactivity was the major problem and resulted in the introduction of second-generation assay in 1997. In 1999, the linearity is improvised in third-generation troponin T assay. In 2007, the fourth-generation assay using fragment antigen-binding (FAB) of two cTnT antibodies is developed. The new high-sensitivity cTn assay is the improvised fourth-generation assay with the sample amount upto 50 µL and buffer optimization through background noise cancellation.

Heart-type fatty acid binding protein (H-FABP), a responsive cardiac biosignature was discovered in 1988 by Professor Jan Glatz for the detection of myocardial within one to three hours of pain. Vupputuri et al (2015) and other research groups studied and evaluated in accordance with which heart type protein could remain used whilst early diagnostic quantitative marker in heart attack patients [17]. The simultaneous measurement of cTnI and C-reactive protein (CRP) was achieved by developing an electrochemical immunoassay by Zhou et al (2010) based on microfluidic chips [18] and the carbon fibre electrode was surface modified to increase the assay performance.
Lee et al (2012) developed a polyaniline (PANI) nanowire biosensor with greater biosensing ability, good biocompatibility to monoclonal antibodies by integrating with microfluidic microchannels for the detection of myoglobin (Myo), CK-MB, cTnI, and b-type natriuretic peptide (BNP) [20]. Philips Minicare I-20 point-of-care (POC) system could care by testing in the patient vicinity for people enduring chest pain when they turn up at the hospital or health care. Minicare work through blending of novel materials in the blood sample, and the sensor can perceive and compute the amount of a given cTnI biomarker [21]. The biggest challenge in POC is doctor’s confidence level and reliability.

Jasper et al, studied the clinical execution of high-sensitive cardiac troponin I assay in POC device in people with myocardial infarction and compared with central laboratory assays and resulted high diagnostic accuracy in early detection. Though the higher efficiency of the POC-hs-cTnI resulted direct triage toward rule-out or rule-in without the need of serial sampling, there has been lack in overall performance of central laboratory testing i.e.., higher number of analytically false-positive results. Table II list the currently available POC devices.

B. Discussion

Throughout the course of this review, it has been very evident that research and vast advancement of diagnostic technology and delivery of health care services has resulted in an increase in the demand of POC devices especially in primary care, emergency care

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and urban health centers. With recent advancement, POC can lead to increased and improved patient outcomes. But it can replace the conventional laboratory testing if the result is accurate and authenticate. But that not true. The POC devices can act as better substitution in diagnosing. The major advantages or purpose of using POC are reduced time to obtain results of diagnostic testing, decline in pre and post analytical mistakes such as mishandling/ mislabeling of patient specimen, delayed reporting of critical results, clinicians' convenience, lessen the patient visiting time and finally the best patient outcome. The major drawback of POC devices is diagnostic accuracy in terms sensitivity and specificity due to low concentration sample. Human errors are also included due to sampling inaccuracy, lack of knowledge. A device with quick, accurate, authenticate, user friendly, small, easy-to-use, pre-analytical error proof should be designed for wide implementation in all the health centers and reduce the overall cost of the diagnostic devices.

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TABLE II.
POC devices for detecting cardiac markers

Manufacturer & Device	Device type	Cardiac biomarkers
Alere, Triage Cardiac Panel	Portable type	CK-MB, Myoglobin, Troponin I
Abbott, i-STAT	Handheld device	cTnI, CK-MB, BNP
Trinity, Meritas	Portable	hs-cTnI
Response Biomedical, RAMP	Benchtop analyser	D-Dimer, NT-proBNP, Troponin I, Myo, CK-MB
Siemens Stratus, CS	Benchtop analyzer	Troponin I, D-Dimer, NT-proBNP, hsCRP, beta-HCG, CK-MB, Myo
bioMerieux, Vidas Ultra	Benchtop analyzer	hs-cTnI, CK-MB, Myo
Roche, Cardiac T Quantitative	Handheld device	cTnT
Cobas h 232 POC system	Handheld device	Troponin T, NT-proBNP, D-Dimer, CK-MB
Minicare I-20	Handheld device	cTnI

C. Conclusion

Diabetes Mellitus and cardiovascular diseases were one of the major contributing sectors for the research and growth of POC diagnostic devices. Over population and under-staff in the emergency department is a serious barrier to provide the best health service. The POC devices reduce the pressure or crowd on emergency departments, faster triaging and better rule-in/ rule-out decision making and fulfill the healthcare development goals of ‘no one left behind’ in terms of effective health services, efficient health systems, better patient outcome and faster discharging rates. Testing near the patient bed-side, has grown drastically. POC have been more efficient and effective for early detection and treatment, and faster field triage. Successful innovation and development of new devices which makes POC as near-future.

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