COMPREHENSIVE APPROACH TO AUTOMATION OF LABORATORY RESEARCHES IN MEDICAL INSTITUTION

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Abstract. Approaches to the decision of the actual tasks facing to clinical diagnostic laboratories during their automation are described. Construction requirements of laboratory information system and feature of its integration into the structure of unified information system of medical institution are reviewed. The multilevel modular principle of laboratory information system construction is described. The brief description of software complex composition, functions and structures and, also, applied algorithms of information streams processing is given.

Introduction

In all branches of knowledge increase of rates of scientific and technical progress is marked. Theoretical knowledge in medicine and biology have essentially extended and have gone deep. However these achievements are impossible without progress in the related subjects providing diagnostics and monitoring, assisting to estimate efficiency of medical actions. On world statistics, during the last decades use of clinical laboratory researches exponentially increased also this growth proceeds. Clinical diagnostic laboratory (CDL) occupies large part in structure of diagnostic researches, both by quantity of researches, and on the clinical importance of results of testing. Results of laboratory tests are the important source of diagnostic information for a modern level of the organization of medical diagnostic process [3].

Peculiarity of laboratory diagnostics is mass service of patients at routine inspections, outpatient reception hours, in hospitals, diagnostic centers, specialized laboratories and use of laboratory analyzers.

Automation of CDL processes is actual and has the big practical value. Use of laboratory information systems (LIS) becomes the standard in CDL activity. Thus the basic purpose of LIS is real-time information support of the medical personnel by results of the carried out tests, effective realization of functions of laboratory due to management of information streams, gathering, analysis and processing of the data, that is received as result of laboratory researches carrying out. Introduction of LIS in all subdivisions of laboratory and use of statistics enables to analyze an overall performance and to compare economic feedback from various kinds of researches [4].

The main preconditions for creation of LIS are:

- significant document circulation between clinical branches and laboratory;
- performance of a plenty of tests;
- presence of high-efficiency analyzers, the information with which can be transferred directly to information system;
- necessity of increase of reliability and quality of laboratory researches;
- aspiration to facilitate routine work of employees of laboratory;
- creation of a database for scientific researches, including for development of diagnostic algorithms.

1. Brief review of existing laboratory information systems

It is necessary to note, that developers of such systems often had to choose between quantity of the procedures realized by system and their functionality. It has been caused by both insufficient productivity of PCs and software development difficulties. And only in the last years creation of really fully functional diagnostic software complexes serving a lot of medical tasks [1].

Works on creation of LIS were carried out in Russia, Germany, the USA, Canada, etc. The most significant development in this area are: ILIMS (http://www.ilexmedical.com/), ALTEY Laboratory

(http://www.altey.ru/), MEDAP-LIS (http://www.ank-sia.com/), ALIS (http://www.medcore2000.ru/), INTERIN (http://www.interin.botik.ru/), VIDAR (http://www.vidar.ru/).

Use of foreign analogues is complicated because of:

- particular features of construction of our public health services system are not taken into account;
- they are closed systems, as a rule, therefore the decision of a problem of construction of the effective interface between clinical information system and LIS it is practically impossible or it is expensive and long process;
- problem of technical support of foreign LIS is rather burdensome during its maintenance;
- cost of domestic and foreign LIS differ strongly.

Now CDL use this or that kind of the automated information systems. Only some of them use LIS as the unified system uniting all subdivisions in laboratory. Still the smaller quantity of medical institutions has the LIS, integrated with clinical information system though due to development and introduction of local networks the situation quickly varies.

2. Requirements to LIS

LIS configuration for each specific laboratory in many respects depends on its structure, arrangement, equipment and analyzers, and also volume of carried out researches. In this connection the general requirements to LIS can be formulated as the following positions [4]:

- an opportunity of input of results of laboratory tests;
- conformity of introduced system both domestic, and to the international requirements and standards of laboratory practice;
- maximum full fixing data on executors and the manipulations which have been carried out with tests which have arrived in laboratory;
- LIS should be adapted (entering of the reference information: establishments of the customers, new methods of research, normal values, etc.);
- access from the common clinical information system, i.e. doctors should have an opportunity to order tests and to receive their results in computer variant, and experts of laboratory - the additional information on the patient;
- reliability of functioning of LIS, security from failures in work and ability to self-restoration, and also the organization of reserve copying of the data.

3. Construction of information model

The process of information system realization can be divided into two stages. At the first stage the knowledge domain is studied and the information model is under construction. At the second stage on the basis of the constructed information model the program system is created.

Sources of the information for construction of information model are document circulation and experts of laboratory. As well as in any other organization, passage of documents through CDL is accompanied by the certain procedures of the coordination, the statement and signing of documents and the control over their origin [2].

At construction of CDL information model it is necessary to describe and carry out a planning of working streams. As an element of decomposition of medical diagnostic processes the concept of elementary service is accepted. It is represented as the some semantically complete action of the personnel on various objects (patients, materials, test tubes). Services are appointed, planned and appear in the interconnected processes purposing the various purposes object.

As a result of the received information analysis, elementary functions of personnel activity have been allocated, entrance and target information streams are determined.

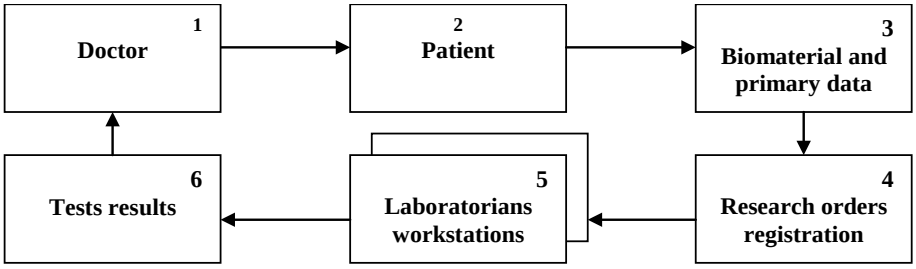

Fig. 1. Technological process of laboratory activity

As a rule, model of functioning of laboratory following:

- at the laboratory input there are research orders and a biomaterial;
- performance of researches on analyzers and manual data input;
- data import from analyzers;
- confirmation of the entered data with the indication of the executor and the date;
- at the laboratory output there is a data set: results of researches and statistics.

4. Levels of realization of information technologies in LIS

Specialization in laboratory medicine is consequence of development and perfection of laboratory - diagnostic service. Division of laboratory service on independent hematological, biochemical, immunological, serological and other specialized laboratories or their work in structure of the centers is one of the bases for use of several levels of realization of information computer technologies [8].

The suggested comprehensive approach to automation of laboratory consist in construction of a functional subsystem which is integrated into unified informational analytical system on the basis of electronic case record (UIAS). UIAS is intended for the comprehensive decision of medical institution tasks.

The multilevel modular principle is put in a basis of development of information technologies in CDL:

- directly at the level of the analytical equipment;
- at the level of the workstations, the workgroups;
- in structure of networks of the top level (information complexes - UIAS) with access to external sources of the information.

The given principle of construction provides an opportunity of gradual growth of number of workstations and workgroups on a measure of occurrence of requirement. Adaptation of system or its components is facilitated at duplicating on other laboratory services.

For most effective utilization of LIS in structure EIAS the concept of “intellectual productivity” has been accepted. Realization of this concept means use of a unified database between LIS and UIAS. Common information space allows optimal way to decide a task of construction of intellectual analytical systems on the basis of the information from a database.

“Intellectual productivity” is reached, on the one hand, due to processing the big number of tests, including gathering and the analysis of the information from laboratory analyzers. On the other hand, LIS is realized on the basis of networks and it is included in structure EIAS with use of modern technologies and algorithms of laboratory testing, that objectively raises validity of research orders for laboratory diagnostics. That is LIS acts as a separate subsystem of gathering and processing of results of tests, thus giving the resources for UIAS.

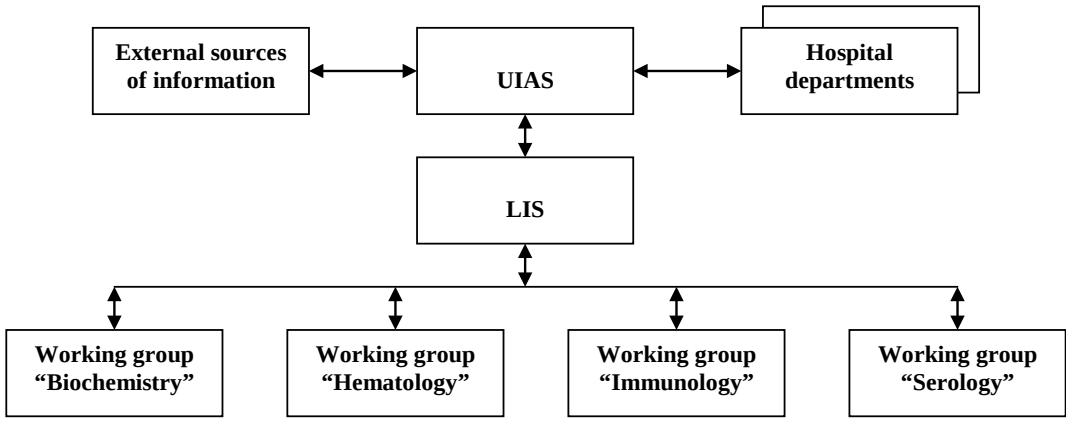

Fig. 2. Structure of the automatic control system of laboratory

5. Features of realization

We aimed to keep maximum whenever possible algorithm of work of employees of laboratory developed earlier and sequence of technological operations to avoid excessive difficulties on development of new approaches and to facilitate introduction of system in daily practice.

The developed algorithms are directed on simplification of procedures of search, input of results, laboratory information perception.

In an automatic mode algorithms of calculation of a various sort of derivative values are applied on the basis of the laboratory information.

In a research order the following data on the patient are taken into account: number of a card, number of the case record, full name, gender, department, type of a sample, and also current working number of the test, number of the attending physician, number of the executor. The form of results includes names of a parameters, results, units of measure, normal values, date of carrying out and the executor.

Access to a unified database has demanded development of special filters of the information which provide reception of the necessary data in the integrated and clear kind.

Electronic documents have the status - a state of the document. The state specifies a urgency of the document. Not the actual document does not leave from system as on it there can be references, and it needs to be shown at access under the reference from other documents.

For the organization of safety and security of the information in a database it is used dynamic configuration of workstations. Function - the minimal action translating system from one steady state in another. We consider function as unit of configuration of a workstation and as unit of definition of the rights of access to the information. For example, subtree of functions for work with the test: creation of a research order (the initial form of the test), editing of the test results, editing of the executor, viewing of test results, deletion of the test results. Thus, the approach known from technology of programming as "bottom-up" when in the beginning separate functions are realized from which then the ready program is packed.

Configuration of workstations occurs at a level of carried out functions, the information about which is stored in a database. The workstation for the majority of users does not depend on a concrete computer, except for cases when such computer is connected to the unique equipment (for example, laboratory analyzers). The information about configuration workstations can be stored only in a database. Thus the information on functions of each registered user is stored in a database. In the menu of a concrete workstation there is an access only to those functions to which the user has the right.

In LIS the following functions are realized:

- registration of laboratory research orders and biomaterials;
- input of research results from analyzers and manual input;
- the automatic control of results on conformity to norms;
- forming and printing of research results;
- forming and printing of statistics on laboratory;

– the account of expenses of time for performance of researches;
– setting by the user of samples of screen forms.

Quality of laboratory researches raises due to exact performance of each stage of technological process as unlike the person the machine reproduces the same sequence of manipulations with constant accuracy much better. Productivity of carried out researches raises due to use of modern analyzers which can carry out hundreds and even thousand tests per hour. In result efficiency of use of the laboratory equipment raises. The key moment of increase of productivity of LIS with use of such analyzers is presence of the interface for their connection.

Real use of LIS speaks about achievement of tasks in view. It is created on the basis of advanced program technologies as Microsoft Windows application with the use of client-server architecture. Its structure includes a database of patients and the carried out examinations.

Since 2003 LIS is used in several Minsk medical institutions. The main users of LIS are: the Republican scientific practical center "Cardiology", the 432 main military clinical hospital, the 10th city clinical hospital.

Use of LIS during clinical trials has shown its high value for the decision of tasks of improvement of quality of carried out tests, reduction of time from the moment of receipt of test in laboratory till the moment of reception of final result and costs of tests performance.

The given work is carried out within the framework of the state program of information of public health services system of Belarus.

Conclusion

Approaches to the decision of actual tasks of CDL automation are reviewed. Requirements to construction of LIS and features of their integration into structure of unified information system of hospital are described. The multilevel modular principle is put in a basis of development of LIS: workstation - workgroup - LIS - integration of LIS into structure of unified system of hospital. As a whole CDL automation has allowed to increase the quality of laboratory researches, to reduce the delivery time of test results to physicians, to generate the statistical reporting on laboratory faster and to create a database for scientific researches.

Essential task for the nearest and perspective periods is the development of the concept of the further enhancement of LIS in which a priority direction is the information exchange of diagnostic reports between various hospitals. Enhancement of system to work with the images, received on laboratory microscopes is provided. Digital processing of the received images will allow to carry out their additional analysis.

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