Notes

25

AUTOMATION IN CLINICAL LABORATORY

25.1 INTRODUCTION

The word automation is inspired by word automatic. Automatic means exercising control without interference. So automation means getting work done by machines which can run on their own without our continuous monitoring. Automation refers to machines with intelligence and adaptability which reduces our workload and need for nonstop supervision.

OBJECTIVES

After reading this lesson, you will be able to:

- define automation
- list the uses of automation in clinical lab
- discuss automation at each step of analysis
- describe different types of auto analyzers
- enlist the advantages and disadvantages of automation

25.2 AUTOMATION IN CLINICLA LABORATORY

There are several individual steps in the analysis process as a whole in a laboratory such as:

1. Identifying the patient
2. Getting the correct sample
3. Identifying and proper labeling of the sample
4. Delivery of sample in proper storage condition and within time

Notes

5. Preparation of sample for test
6. Sample loading/aspirating
7. Analysis
8. Reporting
9. Entering in register

Imagine if you are asked to add from no 1 to 100 and write the result throughout the day. How would you feel? Can you assure that after 2 hours of repeating the same task you will not be bored and make mistakes? But an automated machine will never feel tired nor make mistake as often as you will.

Automation has a lot of benefits for the laboratory personnel.

1. Reduces the workload
2. Increases turnaround time (Saves time used per analysis)
3. Increases total number of tests done in less time
4. Eliminates repetition and monotony from human life so decreases human error, improves accuracy
5. Improves reproducibility (repeatability)
6. Uses minimum amount of sample and reagent

In a clinical laboratory set up automation is useful in routine chemistry, hematology, immunological assay, and daily processing of large number of samples etc. Usefulness of automation in advanced and well equipped clinical laboratory can be also extended to

1. Transport of specimen
2. Processing of specimen
3. Loading of specimen into auto analyzer
4. Assessment of results of performed tasks

However, if above steps are not automated due to lack of finance and infrastructure, still any ordinary laboratory at least go for automation in its analysis step. The routine techniques and procedures that are done manually by technicians are replaced by automated analyzers called AUTOANALYZER.

INTEXT QUESTIONS 25.1

State true or false

1. One of the benefits of automation is that it saves reagent
2. One of the benefits of automation is that it reduces turnaround time

3. The total number of tests is decreased by automation
4. Automation improves reproducibility
5. Automation is has no use in hematology
6. Transport of sample is not part of automation of laboratory

In the beginning of this lesson we enlisted 9 number of steps involved in entire analytical process for a laboratory. Let us see the possibility of use of automation in some of these steps.

25.2.1 Sample collection

The use of glucometer is one such example where just by pressing a button on finger tip, the finger is pricked with least pain and analysis is also done then and there.

However, not all tests can be done in glucometer. So, automation in sample collection mainly refers to improved, faster and least discomfort causing techniques of collection. Such as: robotic system, vacutainers etc.

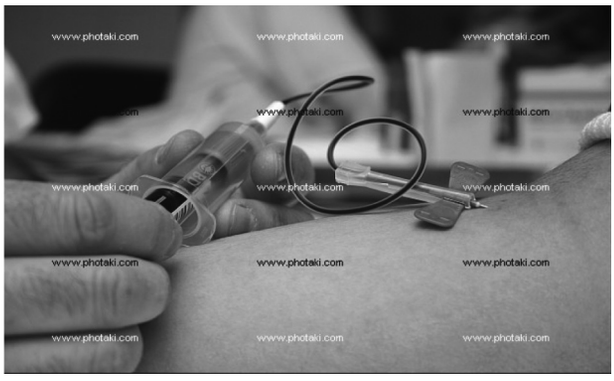


Fig. 25.1: Blood collection with vacutainer

Blood collected using a vacutainer. Here the phlebotomist need not pull the syringe, blood gets sucked in due to negative pressure filling the vaccum

Fig. 25.2: Vacutainer

Different types of vacutainer for serum collection and for plasma collection using different types of anticoagulants. The identification is done with the colour of caps used.

25.2.2 Sample identification by Labeling and bar coding

The laboratory information system comes into take part here. It first generates a unique identity or hospital number for each new patient. A record is maintained thereafter for him/her. All sample collected have to bear the name and details of the patient along with this unique identity (hospital number). The same is used while entering the details into auto analyzer software and result is also published with this number and other details.

Some advanced labs are using computer generated bar coding technology for labeling samples. It has the advantage that it can be scanned and read by bar code reader accurately so transcriptional error (mistake in writing manually) is avoided.

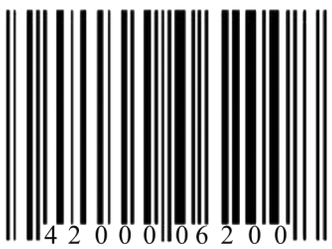


Fig. 25.3: An example of stickers with bar code

Fig. 25.4: Different samples with different bar codes pasted on the tube

Fig. 25.5: Bar coding of patient

Bar coding of the patient,unique sample identity is attached to his/her wrist. Even when patient is sleeping or unconscious, nurse can read the code for patient identification.

Fig. 25.6: Bar code in Blood collection

Bar coding of blood bag in hematology, stores entire detail of type of blood, its components, storage condition, time of storage etc just by bar codes

25.2.3 Sample delivery

Most of the laboratories rely on human pick up system or conveyer belt system. Though cheaper, it may lead to human error, delays etc.

Pneumatic tube systems (use of pressurized gas to move the tubes containing samples) are used in some laboratories. However, care has to be taken that acceleration and deceleration should not damage any sample.

In very advanced laboratory mobile robots are used.

Fig. 25.7: A sealed sample container at left

Fig.25.8: A container to transport blood culture

The pneumatic tube systems at right sample which can fit into all pneumatic tube systems

25.2.4 Sample preparation

Most of the labs depend on technicians for sample processing (such as serum separation) as soon as sample arrives. However introduction of automation can reduce the workload on technicians and save their time and expertise for analysis purpose. Therefore, now days many semi automated devices are developed which can analyze whole blood itself. For example, automated ion selective electrode, use of dry chemistry etc.

The automated sample processors come in 2 types:

- Stand alone automated sample processors and
- Independent automated sample processors.

These automated sample processors can do the following tasks: sorting of samples, removing caps, separating samples, bar coding etc. having an automated sample processor solves the task of bar coding and sample delivery via conveyer belt system.

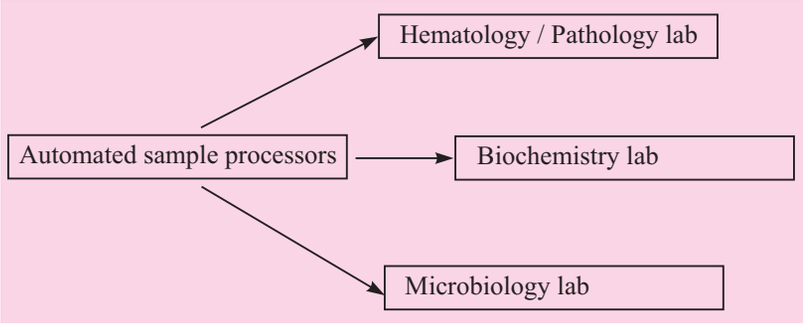


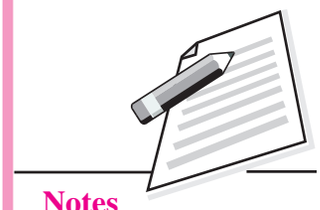
Fig. 25.9

The arrow mark represents pneumatic tube system or Conveyer belt

INTEXT QUESTIONS 25.2

Match the following

1. Sample collection	(a) Pneumatic tube systems
2. Sample identification	(b) Autoanalyzer
3. Sample delivery	(c) Different coloured caps
4. Plasma	(d) Bar coding
5. Sample analysis	(e) Vacutainer



25.3 SAMPLE ANALYSIS

Now let us study briefly about each aspect of automation in the analysis process itself which is the minimum essential aspect of automation for any laboratory. For automation in analysis process we have invented auto analyzer.

25.4 TYPES OF AUTO ANALYZERS

Auto analyzers based on above principle can be divided into two types

- Open system
- Closed system

25.4.1 Open system

In this system, the operator has the advantage that he can purchase reagents from any company so he can save money by buying reagents which are cheaper thereby reducing the cost per test.

In a modular design: An auto analyzer is designed by assembling pulling together of all parts. This increases the flexibility of machine according to customer's demand.

For example: Ion selective electrode. Due to modular approach, the facility for analysis of sodium, potassium and chloride can be built into the system or can be added later on.

25.4.2 Closed system

In this system the operator has to buy chemicals only from a particular company, because reagents from different companies will simply not be accepted by the machine, so machine will not run. So operator can not reduce the cost per test.

Next, reagents have to be provided in unique containers or format as prescribed by its manufacturer. This too adds to cost per test.

However, it allows high degree of automation.

Laboratory can be managed by just one or two well trained technical assistants.

The automated machines are designed to function as either a modular system or an integrated system.

Modular system in auto analyzer

Compare it with modular kitchen where there are many smaller cabinets fitted according to its use. So if there is a problem with any part, only that part is

replaced without disrupting the rest of the kitchen. Similarly, in a lab when whole automated system is subdivided into multiple useful parts it becomes a modular designed automation. Each part is created separately in such a way that they can fit into different systems. It is useful because if one part of machine is out of order, it can be replaced without affecting the entire machine. One such example is: Roche Modular P auto analyzer.

Fig. 25.10: A modular kitchen

Fig. 25.11: A modular kitchen see the different types of cabinets

Integrated system in auto analyzer

In integrated system, the entire equipment is designed in such a way that every part in an essential part of the machine. Basically it is possible due to the merging of the functionality of different softwares into one integrated solution.

It also comes with the disadvantage that service and maintainance may be difficult and expensive too. We have to rely on company engineers every time even for a minor service.

However, it offers a lot of advantages such as

- Improved communication
- Improved data exchange between different softwares and the machine

Now let us understand different types of processing by auto analyzer. It is broadly of 2 types:

(a) **Continuous flow processing:** Based on this principle a continuous flow analyzer (**CFA**) is **made of different modules**, such as:

Sampler

Pump

Mixing coil

Heater/incubator

Sample treatment chamber (dialysis, distillation etc)

Signal detector

Read out device (data generator)

This provides one analysis per analyte for one sample at a time. **The flowing carrier solution passes through small tubes continuously. This is the main principle of Continuous flow processing.** Here sample is injected into a flowing carrier solution. The sample mixes with diluents and reagent and it is sent through the tubing and mixing coils. **The machine prevents carry over effect between different samples by injecting bubbles of air**. The air bubbles literally create separate space for different reactions to take place inside the tubing and mixing coils.

The tubing passes the samples from one apparatus to the other. There are different apparatus for different functions, such as ion exchange, heating, incubation, and finally recording of the signal.

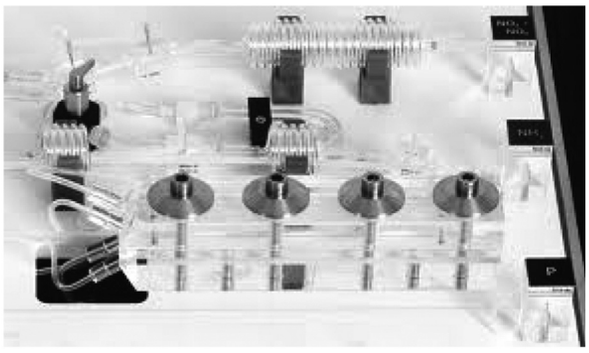


Fig. 25.12: Note the complex pattern of tubing system in a CFA

The flow conditions are regulated. When reaction is taking place, the optical density of the colour formed is read and results are obtained. So we do not have to wait till the reaction ends. It has separate heater for promoting enzymatic reaction and colour development.

Let us take one example for better understanding. In a nephrotic syndrome patient you want to analyze total protein, albumin and creatinine. In case of continuous flow processing analyzer the patient sample will be sucked by the instrument and injected into the tubing with reagents for protein, and diluents

(if needed). Next air bubbles will be injected and patient sample will be sucked again. This time instrument will inject reagent for albumin. Mixing will be done inside the tubing and mixing coils. Again the process will be repeated for creatinine estimation. The 3 reactions will occur inside the same long tubing but they will remain separate due to air bubbles in between.

As the sample and standard are treated in the same manner, mixed in same condition, travel the same length of tubing, it removes the difference between the two. So the difference in reading for test-tube from that of standard gives the answer.

Even though originally, CFA was designed to process only colorimetric reactions, later on CFA were designed to read reactions based on ion selective electrode, flame photometry, flurometry etc. depending on the need of the laboratories.

The major uses is for batch analysis such as liver profile, lipid profile, renal profile assay etc.

There is certain disadvantage in this system:

- **Even when there is no test to be done, reagents are drawn to maintain the flow**. This adds to the cost per test.
- Maintainance of instrument is required more frequently.
- The probe and internal tubings must be free of colgs. **When there is no sample the probe must be dipped in distilled water to avoid blockage or precipitation.**
- The machine itself occupies large space.

Fig. 25.13: Image of an aut analyzer based on continuous flow analysis

(b) **Discrete processing:** in this type of auto analyzer, each sample is provided a discrete space. It means **each analysis even for same analyte or sample takes place at different cups. This is the main principle of discrete processing**.

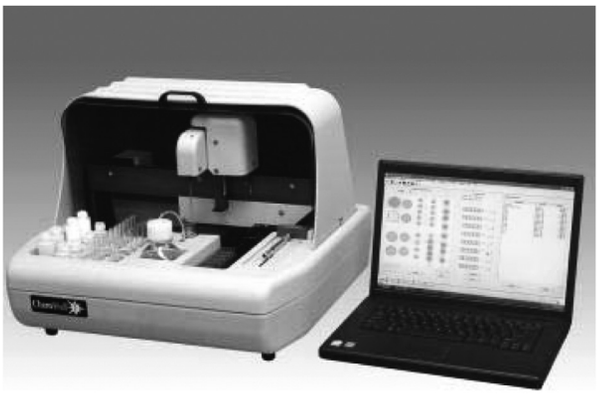


Fig. 25.14

Let us take the previous example of the nephrotic syndrome patient again. You want to analyze the same 3 parameters: total protein, albumin and creatinine. Now, in case of discrete processing analyzer the same patient sample will be sucked by the instrument and poured into 3 different cups. Then reagents for protein, albumin and creatinine and diluents (if needed) will be added. Mixing will be done. Cups will be read at different times to give results.

Exact amount of sample and reagent is aspirated and mixed. So there is no loss of excess reagents used for flow as in continuous flow processing. As each analysis is done in different cups and read in different cuvetes, **there is no carry over effect at all**. So literally each analysis is discrete from each other.

- This is more useful
- Saves reagent cost and hence popular than continuous flow analysis.
- No sample carry over effects

Based on this principle the auto analyzers developed into two different varieties such as centrifugal analyzer and random access analyzer.

25.4.2.1 Centrifugal analyzer

Sample and reagents is pipette into different chambers on a rotor. The centrifugal force is used for transfer and mixing of sample and reagents. Rotor moves the final product upto the optical system for final reading. This is time saving for batch analysis because all cuvets can be read at a time. But its disadvantage is that only one test can be performed at a time.

25.4.2.2 Random access analyzer

Each sample can be analyzed for multiple tests, and multiple samples for one test also can be done by giving appropriate commands to computer software. It

is the **most versatile of all type analyzers**. Let us say we have 3 different samples. First one needs renal profile, second one needs only glucose and urea and third one need triglyceride, albumin and calcium. So the technician has to simple take 3 different sample cups and loads 3 samples. Then he has to enter sample number, cup number and the tests required. And when he presses the start button tests will be done automatically.

Fig. 25.15

INTEXT QUESTIONS 25.3

Match the following

1. Modular design	(a) No carry over effect of samples
2. CFA	(b) Air bubbles separate samples
3. Integrated design	(c) Most versatile analyzer
4. Discrete analyzer	(d) Removal of parts easy
5. Random access analyzer	(e) Improved communication

25.5 REPORTING

The entire hospital information system can be linked to automated instruments and reporting authorities' desktops. So as soon as a sample report is ready, information goes to reporting officer's computer.

After he/she approves the result, the same is displayed in all computers in the hospital. So the clinician or nurses awaiting the report can check at regular intervals for the report and after matching the patient's unique hospital number they can directly take a print out of the report.

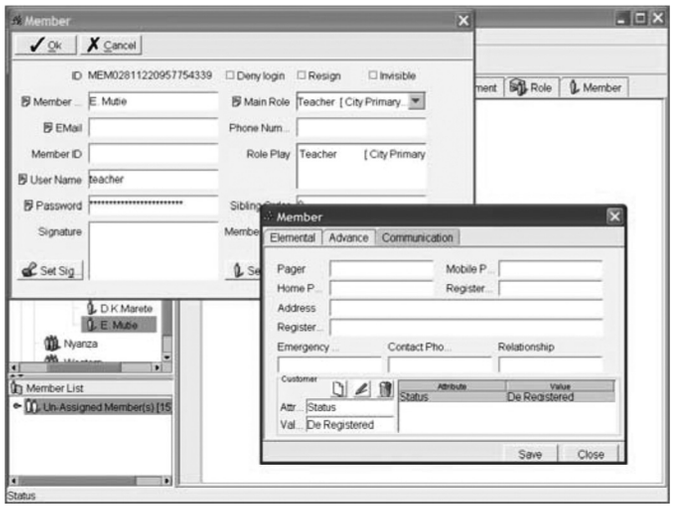


Fig. 25.16

This minimizes the time delay in reporting and manual report delivery.

Some problems faced in automation in lab

1. Lack of trained personnel at every aspect of automation
2. Automation may not work in a system where administration wants to reduce cost at every step
3. Hidden costs: trained personnel, supply and maintainance, system upgrading, service

Therefore, till now in many labs of our country you will not find entire system automated. However, most of the labs use automation in the form of automated analyzers discussed in this chapter for this purpose.

INTEXT QUESTIONS 25.4

1. An open system analyzer saves money by reducing .....
2. A modular system is flexible because its ..... can be replaced without affecting entire machine.
3. The main feature of CFA is that, a flow carrier solution runs through it .....
4. The main feature of discrete analyzer is that each reaction takes place discretely .....
5. Which analyzer is associated with minimum carry over effect? Choose between CFA and discrete analyzer.
6. One disadvantage of automation is ..... cost What have you learnt

WHAT HAVE YOU LEARNT

- Analysis in lab can be automated right from the step of patient identification upto report delivery. However, due to the hidden cost and demand of trained personnels at each stage most of the labs restrict their automation only at the laboratory analysis level. This is mainly done by auto analyzer. Modern auto analyzers run mostly on the principle of discrete analysis where each analysis takes place in different cuvets, avoiding carry over effect. Random access analyzers are the most versatile type where multiple tests can be run at any time. Integrated system in auto analyzers improve efficiency but increases maintenance tasks and cost per test.

TERMINAL QUESTIONS

1. What are the individual steps in the analysis process as a whole in a lab?
2. How can you introduce automation in patient identification?
3. Discuss the role of automation in sample identification and delivery.
4. Discuss the disadvantages of CFA.
5. How is discrete analyzer better than CFA?

ANSWERS TO INTEXT QUESTIONS

25.1

1. True 2. False 3. False 4. True 5. False

25.2

1. (e) 2. (d) 3. (a) 4. (c) 5. (b)

25.3

1. (d) 2. (b) 3. (e) 4. (a) 5. (c)

25.4

1. Cost per test 2. Damaged parts 3. Continously
4. In different cups 5. Discrete analyzer 6. Hidden