Full Length Review Article

CONTROL OF THE ANALYTICAL PROCESSES IN CLINICAL LABORATORY: AN UPDATE OF THE LEVEY-JENNINGS CONTROL CHART AND WESTGARD RULES

*Destefani, A. C.

Professor of Biomedicine, Faculty of Biomedical Sciences of the State of Espirito Santo, Brazil

---

ARTICLE INFO

ABSTRACT

The analytical process control is one of the tools of quality management, it is necessary to obtain results of the analytical run within a standard of reliability and accuracy, and required by existing legislation of the country. To maintain control of the analytical run is used statistical tools, and covered here charts Levey and Jennings and Westgard multi-rules, which are used in the main clinical laboratory.

INTRODUCTION

In the context of improving the quality of services to health and the training of professionals in this area, process control is of paramount importance; knowing that it is through him that the company, which became the laboratory, will be consolidated in the labor market and meet customer requirements. With the amount of laboratories currently in the job market, the client looks for a differential in choosing which will link. The lab, in turn, wants to captivate you, then apply methods of marketing, administration among others - once not needed or used - need to integrate each member of your company in this context, noting the client, their longings and increasing their responsibility it (Mugnol, 2006). From the time that the request for examination is delivered to the patient begins a search for which laboratory should choose, always looking for one that gives you more confidence, which is well received with respect; in which he feels good and quiet for choosing (SHCOLNIK, 2009).

---

*Corresponding author: Destefani, A. C.,
Professor of Biomedicine, Faculty of Biomedical Sciences of the State of Espirito Santo, Brazil.

Forms of analysis have improved over time, increasing the perception of errors, whether human or machine, hence the need to believe the lab and elevate it to a higher degree of confidence, many ways to eradicate these errors arose and also ways to avoid it (OLIVEIRA, 2007). The internal quality control has emerged to improve the return to the patient and the quality of it, since it encompasses the clinical consultation to delivery of the report, involving the pre-analytical, analytical and post-analytical phases (LOPES, 2003). To prevent nonconformities and have greater condition to evaluate when and why they happen and graphics cards are able to demonstrate these processes in detail, and some rules for how to be able to help (Westgard, 2005).

Quality Control in Clinical Laboratory

With regard to quality control must first pay attention to the concept and quality control of the words specifically. In the Portuguese language dictionary, control is the administrative, financial and physical condicion/verification. When talking about quality should remember the variety of concepts, including that quality is fitness for use, and / or what the customer wants. To conceptualise quality in relation laboratory analyzes the concept more applicable is that quality should exceed the needs and expectations of its customers and employees, going beyond the expected for these (LOPES, 2003). Quality control is an inherent part of a Quality

Management which tends to control all the processes established by this management, always working with current laws and regulations, avoiding mistakes, hitting them when and if they occur, so as to ensure greater satisfaction customer and employee. Quality control is focused on quality requirements, allowing you to evaluate the precision and accuracy of analytical methods (LOPES, 2003). However the quality is expressed by the client through the satisfaction of service prior to the service desired, therefore, achieve the goals proposed by the client raises the quality of the laboratory. These goals can be achieved by reliability, responsiveness, empathy, safety and responsibility that are transmitted by the laboratory (DAL FORNO, 2005).

Stages of the Analytical Process and Sources of Errors in the Clinical Laboratory

The analytical process includes clinical consultation from the possible information passed to the doctor when needed (DAL FORNO, 2005). The standardization of these processes is a way to minimize errors that may occur, increasing the level of quality and patient trust. (OLIVEIRA, 2007; GRAÇA, 2005; LOPES, 2003). The steps of the analytical process are divided into: Pre-analytical, analytical, post-analytical. All these steps must be registered and have their previously standardized process; specifically in Brazil, RDC n. 302 and updates arequires this standardization as a guarantee of quality, while the RDC n. 50 and updates, in their sixth to seventh paragraph, describes step by step how to be the standardization of pre-analytical, analytical and post-analytical phases - case not followed as required by resolutions can configure potential sources of errors in the process.

Pre-Analytical Phase

According to RDC 302 pre-analytical process begins with past customer information, noting that some samples are not collected in the laboratory or collection sites, so the delivery in writing with appropriate explanations of how to perform the procedures is necessary. Information about how the client should proceed before the collection are of great value. The preanalytical phase is difficult to eradicate error, since most occur before patients enter the lab (LOPES, 2003). Among the error factors in the pre-analytical phase can observe the lack of fasting (required for certain tests), performing physical exercise prior to collection and even the position that the patient is at the time of collection and the time that the material is collected may influence the results (OLIVEIRA, 2007). Having collected the material properly, it is important to note that the identification of the sample should be performed in a standardized and visible - not realizing the lids of the containers - and that should be performed at the time of collection and the identification with photo also noting the rules of standardization of laboratory itself (LOPES, 2003).

The professional responsible for collecting the sample must have knowledge of the whole process and the importance of this as correct homogenization, storage to the place of analysis, the time of collection, when necessary, among other factors. Transportation must be performed by a properly trained professional; and means suitable for this purpose (RDC 302) transport. Throughout the pre-analytical process should be standardized according to current standards, avoiding mistakes and saving you the customer and the environment.

Analytical Phase

It is through the process, the step which comprises the analyte of interest is itself being analyzed. May occur, as in the pre-analytical phase, external factors such as water quality and the analyte itself, as the same may be coagulated or very lysed red blood cells, for example; However, most of the errors are hardly originated technique carried out, for example, unwashed glassware, non-standard pipetting reagents or contaminated and not valid standards, among others. It is of paramount importance prior analysis of the equipment to be used, as well as a training professional who will perform the procedure, and to investigate the reagents to be used (LOPES, 2003).

Post-Analytical Phase

Consists of the whole process customer's sample, where the results are calculated, the analysis and evaluation of reports, if required revision or even restarting the process and their maintenance (RDC 302) after being analyzed. It is important the confidentiality of the results prevailing professional ethics and the certainty of the results presented. Constitute themselves as sources of errors the incorrect typing of reports, the misinterpretation of the results, the wrong patient identification and every error that was not corrected in the earlier stages (LOPES, 2003).

Internal Quality Control

Most errors are non-conformities in the analytical phase (Andrade, 2007), soon to reduce these non-conformities were formulated some controls procedures in the laboratory, or internal controls. According to the RDC 302:

> 9.2 Internal Quality Control - IQC
> 9.2.1 The clinical laboratory must perform Internal Quality Control contemplating:
> a) monitoring of the analytical procedure for the analysis of control samples, with a record of results and data analysis;
> b) defining the criteria for acceptance of the results by type of analyte and according to the methodology used;
> c) release or rejection of the analysis after evaluation of the results of the control samples.
> 9.2.2 For the IQC, the clinical laboratory must use commercial control samples, regulated by ANVISA / MS in accordance with current legislation.
> 9.2.2.1 Alternative ways described in the literature may be used provided that allow the evaluation of the precision of the analytical system.
> 9.2.3 The clinical laboratory must record the actions taken arising from the results of rejections control samples.
> 9.2.4 Control samples are to be analyzed in the same way as the patient samples.

So to validate the analysis and increase the confidence of results, internal quality control formalizes the laboratory procedures (LOPES, 2003). For this control the use of some tools, methods and materials is needed.

Standards Calibrators

According to the RDC 302 is necessary to periodically calibrate the equipment or check the calibration of the same, while the RDC 206 defines calibration as follows:

1.3. Calibration: Set of operations that establish the correspondence between values indicated by a measuring instrument and a reference material for purposes of standardization or adjustment of instruments and / or laboratory procedures.

Therefore, the use of patterns becomes necessary controls to ensure reproducibility of the results and to analyze whether they are in a safe threshold. It is important to stability in the standards promoted by calibrators results should be as accurate as possible (LOPES, 2003).

Controls (control samples)

Samples controls have their results offered by the manufacturer and are used to make both the internal or external control. For the first option has the purpose to monitor the precision and which is more stable and homogeneous as possible is recommended (LOPES, 2003). It is important that they are stored properly; Control samples can be lyophilized or liquid. Lyophilized samples show stability for a long period of storage at room temperature. For both types (liquid or lyophilized) it is important to avoid the effect matrix, then the preferred samples of human origin. It is important to use daily the control samples, regardless of their origin, and pass the results to charts, for example, Levey-Jennings and Westgard rules apply including all analytical results before releasing (PNCQ, 2006).

Statistics in Quality Control

The statistics within the quality control is a procedure for studying the characteristics of the process, with the aid of data in order to make it fit the desired shape (REIS, 2001), reaching the required standards to ensure and maintain the quality expected. The use of statistical quality control (QC) aims at the systematic reduction of variability in key characteristics for product quality (WOODAL, W. H.; MONTGOMERY, 1997). WOODAL, W. H.; MONTGOMERY, et al. (1999) define the use of statistics in CQ as: "A branch of Industrial Statistics, being composed primarily of the following: Inspection, Acceptance Sampling, Statistical Process Control (SPC), Design of Experiments (DOE) and Capability Study processes". This methodology (statistics) associated with clinical laboratory became very useful because through graphs and charts can accuse some nonconformities, reducing both the cost of reproduction - it is possible to eradicate the error by allowing the details of the process - as increase the quality and reliability of the results.

Graphics control Levey-Jennings

According SÁEZ-ALQUÉZAR (2008), Levey and Jennings, in 1950, proposed to plot the results of the differences between the duplicates and the averages on maps, which are now termed as maps (charts) of "Levey-Jennings." The main application of the diffusers Levey-Jennings charts were Henry and Segalove simultaneously analyzing control samples (known values) and patient samples (LOPES, 2003), this assessment was from the graphs that were already used in industry. This chart is designed to more easily identify nonconformities, continuing the internal quality control, because it is through this chart that the data obtained from patient samples are analyzed in order to identify any errors to eradicate it (SHCOLNIK, 2009). The chart is made from two

perpendicular axes (xy), where the average offer to the analytical value at the centerline and standard deviations to plus or minus from the average. All these values are pre-established by calculating the average ($X = \Sigma xn/n$) the results of the values of the control serum (analytical runs twenty days minimum), and calculating the standard deviation from the mean ($s = \sqrt{\Sigma} Xn-X)^2/n-1$) and the coefficient of variation (CV $= (s/x) 100$) (SÁEZ-ALQUÉZAR, 2008). The Levey-Jennings evaluates changes resulting from human errors and / or reagent and / or the device periodically monitoring the evolution of the process. The results can be released, or not, from the graph shown by applying Westgard rules based on these data whether or not the deviations from pre-established standards. In cases of noncompliance, the procedure should be the one filed by the laboratory and analyze carefully for error be found and resolved (LOPES, 2003).

Westgard Rules

It is a set of rules created by Westegard and employees in order to better assess the process, making it ideal for observing and interpreting small changes that may happen during an analytical run. The multiple Westgard rules are based on six different control rules to judge valiabilidade an analytical run, deciding when it can be used or not (Westgard, 2003); three of alert rules and the other three trustees rules (SÁEZ-ALQUÉZAR, 2008), when the first three occur imply a better analysis and if necessary a correction of the analytical process. The three trustees are signs that the analytical run should be discarded to define the error (s) and correct it (s). These rules can be used together or only a few, can be adapted to the reality of the laboratory (Westgard, 2003). This adaptation should be performed by analyzing existing biographical, avoiding the use of rules that do not match the reality which will lead the analytical process to a greater error (LOPES, 2003). All analytical process should be recorded, as well as its results, being stored and being available if necessary (RDC 302). Westgard rules conform to the following organization: 1_3s, 1_2s, 2_2s, R_{4s}, 4_{1s}, 10_x, where: 1_3s is used as a rejection rule results because the result of the control sample will exceed three standard deviations more or less. This rule can only be applied if using two standard deviations (LOPES, 2003): 1_2s in cases of the use of two standard deviations and when exceeded can be used as an alarm for better observation of the analytical run (SÁEZ-ALQUÉZAR, 2008); 2_2s is one of the rules of rejection, because if the result of the control sample exceeded the limit of two standard deviations twice, should be used to rejection (in cases of use of two standard deviations (SD)). R_{4s} is already rejection rule, for four consecutive results exceeding the mean of two standard deviations for positive or negative, which may indicate a random error (Westgard, 2003), likewise the 4_{1s} which is also rejected as there was the occurrence of four consecutive results up or down a standard deviation. The rule indicates that violated 10_x when all analytical run should be rejected because the results are all up or down the middle (LOPES, 2003).

Conclusion

The control of analytical procedures in the clinical laboratory is of paramount importance both to achieve the desired and necessary quality, and to ensure the accuracy and specificity of the process, as seen in the literature. Westgard rules as well as charts and Levey Jenning, are of great aid in control of the analytical process, and remember that there are other valid

statistical tools that can be used for monitoring, assisting in analytical control. Resolutions and norms created should also be used to support both the laboratory and the client: they can and should also be used for laboratory quality management, since only control the analysis process does not guarantee a good result, as has been seen, the control of the analytical process is only part of the control of laboratory management.

REFERENCES

Alburque. Carla. Indicadores de desempenho: da implementação a comparação com o mercado. 2007.

Andrade. Mauricio P. Proposta de estrutura de dados para aplicação em investigações de processos analíticos em laboratórios clínicos. 2007. Universidade de São Paulo, Faculdade de ciências Farmacêuticas.

Arcuri. Roberto A. e Col's. Controle interno da qualidade em citopatologia ginecológica: um estudo de 48.355 casos. 2000. Jornal Brasileiro de Patologia e Medicina Laboratorial.

Brasil. Ministério da Saúde. Biossegurança em laboratórios biomédicos e de microbiologia. 2004. Publicações do Ministério da Saúde.

Cardoso. Carlos A. Comparação de kits comerciais na dosagem de constituintes bioquímicos do sangue em eqüinos hígidos. 2008. Universidade Federal de Viçosa.

Coiado. Olivia C. Simuladores para medição de fluxo de líquidos por efeito doppler para controle de qualidade de equipamentos de ultra-sonografia. Universidade Estadual de Campinas, Faculdade de Engenharia Elétrica e de Computação. Departamento de Engenharia Biomédica, 2008.

Controle de Qualidade Externo e Interno em Imunologia. 2008.

Dal Forno, Nara L. F. Clima organizacional e qualidade em serviços: estudo de caso em laboratório de análises clínicas. 2005.

Graça, Regina M. T. A qualidade no laboratório clinico: uma tecnologia de gestão com ênfase na acreditação. 2005.

Katal. Instruções de uso para soro calibrador para parâmetros de química clinica. 2008. Responsável Técnico: Leonides Rezende Jr. -CRMMG 7382. Edição desta Instrução de Uso: Janeiro/08.

lopes. Homero J. J. Garantia e controle da qualidade no laboratório clinico. 2003. Analisa.

Mugnol. Kátia C. U., Ferraz. Marcos B. Sistema de Informação como ferramenta de cálculo e gestão de custos em laboratórios de análises clínicas. 2006. *J Bras Patol Med Lab,* Volume 42, Número 2 Abril 2006.

Neto. Gonzalo V. RESOLUÇÃO RDC N.º 33, DE 25 DE FEVEREIRO DE 2003.

Oliveira. Gabriel S. L. Estudos de fontes de erros nos processos de flebotomia com ênfase na estase venosa em parâmetros bioquímicos. 2007. Universidade Federal do Paraná.

Pncq. Manual do laboratório participante, programa nacional de controle de qualidade, 2006. PNCQ.

Rdc Anvisa N. 302. Lista de verificação com evidências objetivas. 2004.

Reis. Marcelo M.; Paladini. Édson P.; Epprecht. Eugenio. STCEQ - Um sistema tutorial inteligente para controle estatístico da qualidade. 2005.

Reis. Luciano G.; PIRES. Eder A. Sistemas de gestão de qualidade: custos inerentes e o problema da Descontinuidade. 2005. Revista del Instituto Internacional de Costos, ISSN 1646-6896, nº 4, jan/jun 2009.

Resolução - RDC nº 206, de 17 de novembro de 2006.

Sáez-Alquézar. Amadeo. Controle De Qualidade Em Sorologia. 2008.

SCHMITZ. Vanessa; CHIES. Fabiano L.; BEZ. Marta R. Desenvolvimento de um Sistema de Informação para Controle Interno da Qualidade em Laboratórios Clínicos. 2008. In: Seminário de Informática - RS (SEMINFO RS'2008), Torres, 14 a 16 de novembro de 2008

Secretaria De Estado De Saúde - RJ. Boas Práticas de Laboratórios Clínicos - BPLC no âmbito do Estado do Rio de Janeiro. Diário Oficial do Estado. 1998.

Seki. Mario e Cols. A inovação de valores nos laboratórios clínicos. 2003. *Jornal Brasileiro de Patologia e Medicina Laboratorial.*

Shcolnik. Wilson. Acreditação de Laboratórios Clínicos. 2006.

Teac. Tiburcio H. M. O erro de laboratório é reconhecível, controlável e inevitável. 2006. Rev. LAES E HAES.

Wernke. Rodney, BORNIA. Antonio C. Considerações acerca dos Conceitos e Visões sobre os Custos da Qualidade. 2000. Rev. FAE, Curitiba, v.3, n.2, p.77-88, maio/ago. 2000.

Westegard. James O. Abusos, Mau Uso, e "Desculpas caseiras" para problemas do CQ com Regras de Westgard. 2005.

Westegard. James O. Controle de Qualidade: Interpretação das Regras Múltiplas QC. 2003.

Woodal, W. H.; Montgomery, D. C. Research Issues and Ideas in Statistical Process Control. *Journal of Quality Technology,* v. 31, n. 4, p. 376-386, 1999.

****