QUALITY ASSESSMENT FOR COMPLETE BLOOD PICTURE PERFORMANCE

Thesis

Submitted for Partial Fulfillment of Master Degree in Clinical and Chemical Pathology

By

Maysa Elazab Solyman Ahmed

M.B.B.Ch, Faculty of Medicine, Mansoura University

SUPERVISED BY

Professor. Iman Mohamed Amin Omar

Professor of Clinical and Chemical Pathology
Faculty of Medicine
Ain Shams University

Professor. Dina Adel Fouad Mohamed

Professor of Clinical and Chemical Pathology
Faculty of Medicine
Ain Shams University

Faculty of Medicine
Ain Shams University
2012

﴿ قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا
إِلاَّ مَـا عَلَّمْتَنَا إِنَّكَ
أَنتَ الْعَلِيمُ الْحَكِيمُ ﴾

صدق الله العظيم

Acknowledgement

First of all, thanks to ***ALLAH*** *who granted me the ability to accomplish this work.*

It has been a great honor and extreme pleasure for me to perform this study under the supervision of Prof. Dr. Iman Mohamed Amin Omar*, Professor of Clinical Pathology, Faculty of medicine, Ain Shams University for her meticulous supervision and guidance, I am extremely gratefull.*

I would like to express my deepest and utmost thanks to Prof. Dr. Dina Adel Fouad Mohamed*, Professor of Clinical Pathology, Faculty of Medicine, Ain Shams University, for her sincere guidance and great help. I was honored to be her candidate and to be guided all through this work by her kind and valuable advice.*

TABLE OF CONTENT

List of Abbreviations ..... **I**

List of Tables ..... **IV**

List of Figures ..... **IX**

Introduction **1**

Aim of the work **6**

Chapter 1: ISO 15189 Requirements **7**

1. Scope 9
2. Normative references 10
3. Terms and definitions 11
4. Management requirement 15
5. Technical requirements 24

Chapter 2: Internal Quality Control and Evaluation of Automated Hematology Analyzers **33**

- Pre-Analytical phase 34
- Analytical phase 39
- Post-analytical phase 50

Chapter 3: External quality assessment **53**

- Physical Inspection 56
- Pattern Analysis 57
- Survey methods done by proficiency testing 59

Materials and Methods **73**

Results **95**

Discussion **175**

Summary and Conclusion **191**

Recommendations **197**

References **199**

Arabic summary

LIST OF ABBREVIATIONS

A2LA	The American Association for Laboratory Accreditation
AHAs	Automated Hematology Analyzers
B	Bias
CAP	College of American Pathologists
CBC	Complete Blood Count
CLIA	Clinical Laboratory Improvement Amendment
CV	Coefficient of Variation
CVg	between-subject biologic variation
CVw	within-subject biologic variation
%Dev	percentage deviation
EDTA	Ethylene Diamine Tetraacetic Acid
EQA	external Quality Assessment
EQAS	External Quality Assurance programs
EQC	External Quality Control
Hb	Haemoglobin
Hct	Haematocrit
I	Imprecision
IEC	International Electrotechnical Commission
IQC	Internal Quality Control

ISO	International Organization for Standardization
KPI	key performance indicators
K2-EDTA	dipotassium Ethylene Diamine Tetraacetic Acid
K3-EDTA	tri-potassium Ethylene DiamineTetraacetic Acid
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MCV	Mean Corpuscular Volume
MPV	Mean Platelet Volume
NCCLS	National Committee for Clinical Laboratory Standards
PCV	Packed Cell Volume
PLT	Platelets
PMN	Polymorphonuclear leukocytes
PT	Proficiency Testing
QC	Quality Control
QMS	Quality Management System
RBC	red blood cell
RDW	Red cell Distribution Width
RIQAS	Randox International Quality Assessment Scheme
RM%Dev	Running Mean Percentage Deviation
RMSDI	Running Mean Standard Deviation Index

RMTS	Running Mean Target Score
SD	Standard Deviation
SDI	Standard Deviation Index
SPSS	Statistical Package for the Social Sciences
TV	Target Value
TAT	Turnaround Time
TDPA	Target Deviation for Performance Assessment
TE	Total Error
TEa	Total allowable Errors
TLC	Total Leukocyte Count
TLE	Total Lab Error
TS	Target Score
WBC	white blood cell
WHO	world health organization

LIST OF TABLES

Table No.	*Title*	*Page*
Table 1:	Some pre-analytical sources of errors in blood counts ……	36
Table 2:	Some analytical sources of errors in blood counts ……	40
Table 3:	Some post-analytical sources of errors in blood counts ……	50
Table 4:	Situations leading to erroneous results on automated haematology analyzers ……	50
Table 5:	Desirable Specifications for Total Error, Imprecision, and Bias, derived from intra- and inter-individual biologic variation ……..	62
Table 6:	CLIA Proficiency Testing criteria for acceptable analytical performance ……...	64
Table 7:	Benefits of EQA programs …….	72
Table 8:	LH750 IQC measurements from Feb to March 2012 ……...	97
Table 9:	(EQC) Analysis of Hb for LH750 cycle 34 …..	105
Table 10:	(EQC) Analysis of HCT for LH750 cycle 34 …	106
Table 11:	(EQC) Analysis of MCH for LH750 cycle 34 ...	107
Table 12:	(EQC) Analysis of MCHC for LH750 cycle 34..	108
Table 13:	(EQC) Analysis of MCV for LH750 cycle 34…	109
Table 14:	(EQC) Analysis of MPV for LH750 cycle 34 ...	110
Table 15:	(EQC) Analysis of PLT for LH750 cycle 34 ….	111
Table 16:	(EQC) Analysis of RBC for LH750 cycle 34 …	112
Table 17:	(EQC) Analysis of RDW for LH750 cycle 34 ...	113
Table 18:	(EQC) Analysis of TLC for LH750 cycle 34 …	114
Table 19:	End cycle 34 conclusion LH 750 …….	115

Table 20: LH750 RIQAS summary page cycle 34 sample 7 …… 116
Table 21: LH750 RIQAS summary page cycle 34 sample 8 …… 116
Table 22: LH750 RIQAS summary page cycle 34 sample 9 …… 117
Table 23: LH750 RIQAS summary page cycle 34 sample 10 …….. 117
Table 24: LH750 RIQAS summary page cycle 34 sample 11 …….. 118
Table 25: LH750 RIQAS summary page cycle 34 sample 12 …….. 118
Table 26: (EQC) Analysis of Hb for LH750 cycle 35 … 120
Table 27: (EQC) Analysis of HCT for LH750 cycle 35 … 121
Table 28: (EQC) Analysis of MCH for LH750 cycle 35 .. 122
Table 29: (EQC) Analysis of MCHC for LH750 cycle 35. 123
Table 30: (EQC) Analysis of MCV for LH750 cycle 35… 124
Table 31: (EQC) Analysis of MPV for LH750 cycle 35… 125
Table 32: (EQC) Analysis of PLT for LH750 cycle 35 …. 126
Table 33: (EQC) Analysis of RBC for LH750 cycle 35 … 127
Table 34: (EQC) Analysis of RDW for LH750 cycle 35… 128
Table 35: (EQC) Analysis of TLC for LH750 cycle 35 … 129
Table 36: End cycle 35 conclusion LH 750 ……... 130
Table 37: LH750 RIQAS summary page cycle 35 sample 1 …… 131
Table 38: LH750 RIQAS summary page cycle 35 sample 2 …… 131

Table 39: LH750 RIQAS summary page cycle 35 sample 3 ……. 132
Table 40: LH750 RIQAS summary page cycle 35 sample 4 ……. 132
Table 41: LH750 RIQAS summary page cycle 35 sample 5 …… 133

Table 42: LH750 RIQAS summary page cycle 35 sample 6 …… 133
Table 43: LH750 RIQAS summary page cycle 35 sample 7 …… 134
Table 44: LH750 RIQAS summary page cycle 35 sample 8 …… 134
Table 45: LH750 RIQAS summary page cycle 35 sample 9 …… 135
Table 46: LH750 RIQAS summary page cycle 35 sample 10 …….. 135
Table 47: GEN-S IQC measurements from Feb to March 2012 ……... 137
Table 48: (EQC) Analysis of HB for GEN-S cycle 34 ….. 143
Table 49: (EQC) Analysis of HCT for GEN-S cycle 34…. 144
Table 50: (EQC) Analysis of MCH for GEN-S cycle 34... 145
Table 51: (EQC) Analysis of MCHC for GEN-S cycle 34. 146
Table 52: (EQC) Analysis of MCV for GEN-S cycle 34... 147
Table 53: (EQC) Analysis of MPV for GEN-S cycle 34… 148
Table 54: (EQC) Analysis of PLT for GEN-S cycle 34 … 149
Table 55: (EQC) Analysis of RBC for GEN-S cycle 34… 150
Table 56: (EQC) Analysis of RDW for GEN-S cycle 34... 151
Table 57: (EQC) Analysis of TLC for GEN-S cycle 34 … 152
Table 58: End cycle 34 conclusion GEN-S ……... 153
Table 59: GEN-S RIQAS summary page cycle 34 sample 7 …… 154
Table 60: GEN-S RIQAS summary page cycle 34 sample 8 …… 154
Table 61: GEN-S RIQAS summary page cycle 34 sample 9 ……... 155
Table 62: GEN-S RIQAS summary page cycle 34 sample 10 …….. 155
Table 63: GEN-S RIQAS summary page cycle 34 sample 11 ……. 156
Table 64: GEN-S RIQAS summary page cycle 34 156

sample 12 ……..
Table 65: (EQC) Analysis of HB for GEN-S cycle 35 ….. 158
Table 66: (EQC) Analysis of HCT for GEN-S cycle 35 … 159
Table 67: (EQC) Analysis of MCH for GEN-S cycle 35... 160
Table 68 : (EQC) Analysis of MCHC for GEN-S cycle 35. 161
Table 69: (EQC) Analysis of MCV for GEN-S cycle 35... 162
Table 70: (EQC) Analysis of MPV for GEN-S cycle 35… 163
Table 71: (EQC) Analysis of PLT for GEN-S cycle 35 … 164
Table 72: (EQC) Analysis of RBC for GEN-S cycle 35… 165
Table 73: (EQC) Analysis of RDW for GEN-S cycle 35... 166
Table 74: (EQC) Analysis of TLC for GEN-S cycle 35 … 167
Table 75: End cycle 35 conclusion GEN-S ……... 168
Table 76: GEN-S RIQAS summary page cycle 35
sample 1 ……... 169
Table 77: GEN-S RIQAS summary page cycle 35
sample 2 ……... 169
Table 78: GEN-S RIQAS summary page cycle 35
sample 3 ……... 170
Table 79: GEN-S RIQAS summary page cycle 35
sample 4 ……... 170
Table 80: GEN-S RIQAS summary page cycle 35
sample 5 ……... 171
Table 81: GEN-S RIQAS summary page cycle 35
sample 6 ……... 171
Table 82: GEN-S RIQAS summary page cycle 35
sample 7 ……... 172
Table 83: GEN-S RIQAS summary page cycle 35
sample 8 ……... 172
Table 84: GEN-S RIQAS summary page cycle 35
sample 9 ……... 173
Table 85: GEN-S RIQAS summary page cycle 35
sample 10 …….. 173
Table 86: Target score mean for all studied parameters
analyzed by LH 750 and GEN-S in cycle 34 174

and 35 ……..

LIST OF FIGURES

Fig No.	*Title*	*Page*
Fig1:	Schewart/levey-jenning chart over one month ….	46
Fig2:	1_{3S} Reject when a single control measurement exceeds the mean plus 3s or the mean minus 3s control limit. (Random error) …….....	47
Fig3:	**1**$_{2S}$ The mean plus/minus 2s. In the original Westgard multirule QC procedure, this rule is used as a warning rule. (Random error) ……..…	47
Fig4:	**2**$_{2S}$ Reject when 2 consecutive control measurements exceed the same mean plus 2s or the same mean minus 2s control limit. (Systematic error) ……	48
Fig5:	R_{4S} Reject when 1 control measurement in a group exceeds the mean plus 2s and another exceeds the mean minus 2s. (Random error) ……..	48
Fig6:	**4**$_{1S}$ Reject when 4 consecutive control measurements exceed the same mean plus 1s Or the same mean minus 1s control limit. (Systematic error) ……...	49
Fig7:	10_X Reject when 10 consecutive control measurements fall on one side of the mean. (Systematic error) ……	49
Fig8:	EQC analysis of Haemoglobin by Coulter LH700...	68
Fig9:	Histogram of laboratory result for hemoglobin g/dl ……...	69

Fig10: Summary of all methods (instruments) involved in interlaboratory comparison by EQCA ……..…… 69
Fig11: Report Summary page as supplied by RIQAS.……..……. 70
Fig12: Example of EQC materials which are supplied in set of 12 numbered samples, processed in a certain date according to the instructions of EQC programme ……. 73
Fig13: Coulter Method of Counting and Sizing ……..... 78
Fig14: Principles of automated hematology analyzers …… 80
Fig15: LH750 Hematology Analyzer …….. 86
Fig16: GEN-S Hematology Analyzer ……..... 86
Fig17: Report text section ……... 89
Fig18: LH750 IQC chart for WBC,RBC and HGB ……..... 98
Fig19: LH750 IQC charts for HCT, MCV and MCH ……. 99
Fig20: LH750 IQC charts for MCH, RDW and PLT……... 100
Fig21: LH750 IQC chart for MPV …….. 101
Fig22: GEN-S IQC charts for WBC, RBC and HGB…….. 138
Fig23: GEN-S IQC charts for HCT, MCV and MCH…….. 139
Fig24: GEN-S IQC charts for MCHC, RDW and PLT **.....** 140
Fig25: GEN-S IQC chart for MPV ……..... 141

INTRODUCTION

Proficiency testing (PT) is a type of inter-laboratory comparison exercise in which samples are circulated to the participating laboratories; results are then collected and evaluated centrally. Each laboratory is then informed of its performance relative to the other laboratories in the scheme and relative to either true or consensus result for the sample. Performance is usually quoted in terms of standard deviations and is defined as a method of checking lab performance by means of inter-laboratory comparison achieved value and the consensus or true value. In some schemes participants are given a pass /fail rating. ***(Ramirez et al. ,1992).***

Proficiency testing provides a challenge to laboratory's routine methods and procedures. It also provides feedback to laboratories as to whether they are performing their work in accordance with international criteria for technical competence. A laboratory's participation in proficiency testing activities is a requirement of the accreditation ISO 15189 according to international standards.

(www.a2la.org/.../15189_General_Requirements, 2007).