Biology of C Reactive Protein in Health and Disease

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Dedicated to our family, PhD guide,
and
our adorable children

Preface

Good science always demands independent replication of new thoughts and experimental results and desertion of accepted or the so-called theories in light of more and more reliable evidence. Failure to comply with this trend leads to a tremendous damaging bad science, as with the falsely claimed association/relations between facts, observations, and results. The progress of good science also often requires providence, to make discoveries by accident and prudence of things not sought. Work on the pentraxin proteins, like C-reactive protein (CRP) since the 1970s, has benefited from abundant scientific serendipity, leading to modern-day routine clinical use of CRP measurements and the ongoing diverse research projects to explore the pathophysiological role of CRP in various diseases, be it cardiovascular disease, prominently different cancers, rheumatoid arthritis, infectious diseases, and many others. Some emerging progress has been evolving to extrapolate the role of CRP in new field of disease biology. Works are published regarding the role of CRP in mumps, testicular diseases, and different damaging conditions and some other works that need some prominence also. CRP is a very renowned old molecule. It is the age-old practice to add some more dimensions to its function or importance in clinical medicine. Also targets have always been there for adding new concepts by providing models with CRP being a new therapeutic target, a new drug, a new in-house antibody, and in nanoscience and other fields as a promising molecule of pharmaceutical integrity. The research works are expanding and continuously new bubbles of work on CRP are added in the sea of CRP science. So CRP is always a hot topic.

CRP since its discovery in 1974 is known as a classical acute phase plasma protein which increases in concentration manyfold completely nonspecifically in response to most forms of tissue injury, burn, trauma, infection, and inflammation. In 1994, a new report in the *New England Journal of Medicine* revealed the prognostic significance of even a minor increase in CRP concentration/values in severe unstable angina patients. Later, aftermath works observed the prognostic significance for coronary heart disease of increased baseline CRP values in patients with angina as compared to general population. These findings shoot up an inundation of interest in CRP in cardiovascular disease. The consequence is the subsequent propositions of various thoughts in the functionality of CRP in myocardial infarction, coronary heart disease, ischemia, and others. The field is also very controversial. But for the

sake of best or better scientific tradition, the accumulation or the avalanche of robust evidence coming out will eventually and most probably quite soon settle the disputed (if any) issues by establishing reproducibly valid actual relationships, the genuine pathophysiological effects of CRP, and the clinical utility of its measurement values in disease biology. Thus, the clinical context of CRP in clinical medicine is ever expanding. Meanwhile, the media has also taken it up enthusiastically. Articles are coming out where CRP was pointed as a real cause of heart attacks propounding the thought that CRP could be more dangerous than cholesterol. Thereafter, peer-reviewed papers about CRP were just hyping from prominent researchers contributing the relation or contradiction between CRP and cholesterol. Many researchers were tempted to rename CRP from a nonspecific inflammatory marker to a cardiac risk marker.

But various published works reassign or confidently reassure that CRP is not more dangerous than cholesterol. Still in experimental models, CRP can exacerbate the ischemic tissue damage of stroke and acute myocardial infarction. Through rigorous reproducible evidence, emerging and extinguish erroneous beliefs are coming out. The causal role of CRP should be validated by its epidemiological relationship between baseline CRP values and cardiovascular disease risk. At present, immunoassays and techniques were encouraged for the now universal use of CRP assays in screening for different organic diseases and in monitoring disease activity and response to therapeutic approaches and also for detection of intercurrent infection.

However, measurement of this very sensitive but completely nonspecific biomarker of inflammation and tissue damage is thoroughly useful across the field of clinical medicine, but its baseline values are not that helpful for assessment of cardiovascular disease risk. There are so many compelling evidences that CRP contributes to the pathogenesis of atherosclerosis as CRP is known to bind to low-density and very-low-density lipoproteins.

Commercially available protein preparations used for immunochemical assays are routinely shipped with sodium azide, a potently toxic bacteriostatic compound, added to CRP to prevent bacterial growth. Furthermore, CRP expressed by recombinant bacteria are inevitably contaminated with bacterial endotoxin, lipopolysaccharide, and other potentially bioactive bacterial during pharmaceutical production. These commercially produced CRP preparations containing sodium azide and endotoxin definitely produce varied stimulatory and toxic effects on cell culture, which may be wrongly ascribed to CRP during experiments, whereas authentic pure human CRP itself does not produce any of these effects.

Our goal should be now to project CRP in optimizing some drugs with clinical testing in the hope that this therapeutic approach will provide significant cardioprotection after AMI and in acute coronary syndrome, potentially reduce tissue damage after trauma, confer neuroprotection after stroke, and act as a protective molecule in a wide range of infectious and inflammatory diseases.

Our passions run high in this field when our laboratory published in 2003 that CRP is a glycosylated molecule [Das et. al. 2003]. It breaks the age-old myth that CRP was glycosylated. There was a furious response from some

quarters of research. CRP was differentially glycosylated in different diseases or acute inflammatory conditions encompassing nearly sixteen diseases [Das et al 2004a; Das et. al. 2004b]. We were all bubbling with new thoughts to explore. We explore the immunomodulatory role of CRP in malaria, tuberculosis, and visceral leishmaniasis. These three diseases are not only a problem in India, but the burden of these diseases is increasing worldwide. The effect of CRP on parasitized erythrocytes, on different complement receptors of erythrocytes, helping in clearance of damaged erythrocytes through the circulation is modulated by its glycosylated moiety [Ansar et. al. 2006; Ansar et. al. 2009a; Ansar et. al. 2009b]. Within the short span of this book, we tried to just touch and grease some of the aspects of CRP and its relevance in health and diseases. In the greater hypervolume of CRP, there is so much to enlist or describe, but so little is done. This is our first endeavor to express the multitude facets of this "dynamic biomarker protein" or "constant relevant prevalence (CRP)" in diseases and other acute conditions. We hope to extend our thoughts with more research findings, updates, and experiments in the process of giving birth to our second brainchild in the womb of clinical medicine.

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The original version of the affiliation of Prof Ghosh on page iv was corrected. An erratum can be found at DOI 10.1007/978-81-322-2680-2_12.

Acknowledgments

As our first book, which has taken more than 3 years to be prepared and published, we take this special moment to express our sincere appreciation and gratitude for all those who have contributed in making this book take its present shape.

We thank the "Almighty" for providing us the courage and showing us this day.

We would like to express our deepest gratitude to Dr. Mrs. Chitra Mandal, Ex-Director and Outstanding Scientist, Indian Institute of Chemical Biology, CSIR, Kolkata, and our research supervisor, for giving us the opportunity for shaping our research career. She has not only been instrumental in channeling our thoughts but has also constantly supported us and encouraged us throughout our academic journey. She has taught us the intricacies of scientific research and introduced us to the exciting world of immunobiology and proteomics. She guided us to explore the different avenues of the exciting scientific world. Apart from her, there are friends who shouldered our woes and our happiness whenever needed. We are proud to have met them all in my life. It is not possible to acknowledge them individually in this short span.

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We are grateful to our family for their continuous support and encouragement. We treasure their help, cooperation, support, and encouragement. No word is enough to define the constant support and blessings of our parents. Our parents truly defined for us the word "hardworking."

Finally, lots of love to our children, perhaps the best in the whole world, Master *Saptarshi* and Baby *Tanaz*.

It is worth mentioning our indebtedness to all researchers in the field of C-reactive protein from across the globe. We express our gratitude to all journals of national and international repute, for accepting and publishing our work mentioned in this book. It is the scientific research world that helps us to develop confidence, clear vision, strength for struggle, and courage and stamina in search of the truth and to undertake research touching the human lives.

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We are grateful to Springer, India, and their entire team for accepting our proposal to this book. Thank you all for your constant help and cooperation, which is what has made us complete this work.

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About the Authors

Waliza Ansar, PhD She is an alumnus of the erstwhile Presidency College, Kolkata. She mastered in Zoology with specialization in Fisheries and Aquaculture from Calcutta University. With interest in the field of immunology, she started her research, in 2003, in Indian Institute of Chemical Biology, Kolkata, and earned her PhD degree working on various biological roles of CRP in malaria, leishmania, and tuberculosis. After her postdoctoral research in IICB working on host–parasite interactions, she started her teaching career as a lecturer of Zoology in Presidency College, Kolkata, in 2002. In 2009 she joined Asutosh College, Kolkata, as a lecturer of Zoology for postgraduate students. Currently, she is working as an Assistant Professor of Zoology, Behala College, Kolkata, under Calcutta University. Her current research interest involves various clinical roles of CRP in diseases, pathophysiology of some acute diseases, nanotechnology and therapeutic applications, and stem cell therapy. She has presented her work in international and national symposiums. She has published a number of papers in journals of national and international repute. She also has authored a number of publications and book chapters.

Shyamasree Ghosh, PhD Dr. Shyamasree Ghosh is currently working in the capacity of Scientific Officer (E), School of Biological Sciences, National Institute of Science Education and Research (NISER), Bhubaneswar, an autonomous institute under the Department of Atomic Energy, Govt. of India, currently located in Jatni, Orissa. She graduated from the prestigious Presidency College Kolkata in 1998 in Zoology and was awarded the prestigious National Scholarship from the Govt. of India in the same year. She postgraduated in Biotechnology from Calcutta University ranking second in the university in the year 2000.

With her immense interest in the field of science, touching human lives, she continued her PhD from Indian Institute of Chemical Biology, CSIR, Kolkata, qualifying the National Eligibility Test conducted by Ministry of HRD, Govt. of India. Her PhD work in the field of childhood acute lymphoblastic leukemia (ALL) was accepted in various national and international journals of repute and is cited by the young researchers across the globe. She worked in the field of stem cells and nanotechnology in her postdoctoral

research. Later she joined as a faculty in postgraduate colleges affiliated to Bangalore University. She has authored several publications and book and encyclopedia chapters in reputed journals and books.

Research that tries to decode the complexity of disease with hopes for a better living forms her research interest.

Abbreviations

αGalNAc	Alpha-N-acetyl galactosamine
αGlcNAc	Alpha-N-acetyl glucosamine
αGlcNAc	Alpha-N-acetyl glucosamine
α-L-Fuc	Alpha-L-fucose
α1-AGP	α1-Acid glycoprotein
β-ME	β-Mercaptoethanol
β2-M	β2-Macroglobulin
μg	Microgram
AAG	Alpha 1-acid glycoprotein
AAT	Alpha 1-antitrypsin
ABG	Arterial blood gas
ABGA	Arterial blood gas analysis
ABTS	2,2′-Azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) diammonium salt
AcSGs	Acetylated sialoglycans
ACT	Alpha 1-antichymotrypsin
ACTH	Adrenocorticotropic hormone
ADCC	Antibody-dependent cell-mediated cytotoxicity
ADMA	Asymmetric dimethylarginine
AF	Atrial fibrillation
AFB	Acid-fast bacilli
AFP	Alpha fetoprotein
Ag	Antigen
AGP	Alpha 1-acid glycoprotein
AIF	Apoptosis inducing factor
ALI	Acute lung injury
ALL	Acute lymphoblastic leukemia
ALT	Alanine aminotransferase
AMI	Acute myocardial infarction
AML	Acute myelogenous leukemia
ANS	8-Anilino-1-napthalenesulfonic acid
AP	Acute pancreatitis
APC	Antigen-presenting cell
API	Acute-phase index
APPs	Acute-phase proteins
APR	Acute-phase reactant

APR	Acute-phase response
APRF	Acute-phase response factor
APTT	Activated partial thrombin time
ARDS	Acute respiratory distress syndrome
ARF	Acute respiratory failure
ASO	Antistreptolysin O
AST	Aspartate aminotransferase
B2M	Beta 2-microglobulin
BA	Bronchial asthma
BAL	Bronchoalveolar lavage
BCR	B-cell receptor
BH4	Tetrahydrobiopterin
BP	Blood pressure
BNP	Brain natriuretic peptide
BPB	Bromophenol blue
BPH	Benign prostatic hyperplasia
BSA	Bovine serum albumin
BSM	Bovine submaxillary mucin
BS-TFA	Bis-(trimethylsilyl)-trifluoroacetamide
C. catla	*Catla catla*
C/EBP	CCAAT/enhancer-binding proteins
C3	Complement factor-3
C5a	Complement component 5a
Ca	Calcium
CABG	Coronary artery bypass grafting
$CaCl_2$	Calcium chloride
CAD	Coronary artery disease
CB	Chronic bronchitis
CBG	Capillary blood glucose
CC-16	Club cell secretory protein
CD	Crohn's disease
CD	Cluster of differentiation
CDG	Congenital disorders of glycosylation
CDNA	Complementary DNA
CDR	Complementarity determining regions
CGD	Chronic granulomatous disease
CGT	Conglutinin
CHAPS	3-[(3-Cholamidopropyl)dimethylammonio]-1-propanesulfonic acid
CLIP	Class II-associated invariant chain peptide
CLL	Chronic lymphocytic leukemia
CM	Cerebral malaria
CMI	Cell-mediated immunity
CNS	Central nervous system
CNTF	Ciliary neurotrophic factor
COE	Coeruloplasmin
Con A	Concanavalin A
COPD	Chronic obstructive pulmonary disease

COX-2	Cyclooxygenase 2
CPL	Ceruloplasmin
CPM	Counts per minute
CPS	C-polysaccharide
CQ	Chloroquine
CR	Complement receptor
CRH	Corticotropin-releasing hormone
CRP	C-reactive protein
CRP	C-reactive proteinase
CRP_{VL}, CRP_{TB} and CRP_{SLE}	C-reactive protein purified from visceral leishmaniasis, tuberculosis, and systemic lupus erythematosus
CRP_{VL}	C-reactive protein purified from visceral leishmaniasis
CRRT	Continuous renal replacement therapy
CS	Cigarette smoke
CSF	Cerebrospinal fluid
CTLs	Cytotoxic or cytolytic T lymphocytes
Cu	Copper
CVD	Cardiovascular disease
CVP	Central venous pressure
CVS	Cardiovascular system
DAB	3, 3-Diaminobenzidine
DBA	Dolichos biflorus agglutinin
DCs	Dendritic cells
DHMEQ	Dehydroxymethylepoxy-quinomicin
DIG	Succinyl-ε-amido caproic acid hydrazide digoxygenin
DIP	Distal interphalangeal
dl	Deciliter
DLC	Differential leukocyte count
DM	Diabetes mellitus
DMB	1, 2-Diamino-4, 5-methylenedioxy-benzene
DMSO	Dimethyl sulfoxide
DNA	Deoxyriboneuclic acid
DNP	Dinitrophenol
DPH	1,6-Diphenyl-1,3,5-hexatriene
DSA	Datura stramonium agglutinin
dsRNA	Double-stranded RNA
DSS	Dextran sodium sulfate
DTNB	5′5′-Dithio(bis)-2-nitrobenzoic acid
DVT	Deep vein thrombosis
ESR	Erythrocyte sedimentation rate
E	Erythrocytes
E	Eosinophil
ECG	Electrocardiogram
EDTA	Ethylenediaminetet-raacetic acid
EF	Ejection fraction

EGC	Enteric glial cells
EGTA	Ethylene glycol tetraacetic acid
ELISA	Enzyme-linked immunosorbent assay
EMP	Endothelial microparticle
eNOS	Endothelial nitric oxide synthase
EONS	Early-onset neonatal sepsis
EPC	Endothelial progenitor cell
EPO	Erythropoietin
ER	Endoplasmic reticulum
ESR	Erythrocyte sedimentation rate
ESRF	End-stage renal failure
ET	Endotracheal
E_{TB}, E_{VL} and E_N	Erythrocytes from TB, VL, and normal (N) individuals
Fab	Antigen-binding fragments
FACS	Fluorescence-activated cell sorter
FBS	Fasting blood sugar
FcγR	Fcγ receptor
FcR	Fc receptor
FCS	Fetal calf serum
Fe	Iron
FEV	Forced expiratory volume
FFAs	Free fatty acids
FITC	Fluorescein isothiocyanate
FMD	Flow-mediated dilation
FNG	Fibrinogen
FoxP3	Forkhead box P3
Gal	Galactose
GalNAc	*N*-acetyl galactosamine
GalNAc	2-Acetamido-2-deoxi-galactopyranose
GalNAc T	*N*-Acetyl galactosamine transferase
GCS	Glasgow coma scale
GCSF	Granulocyte colony-stimulating factor
GFR	Glomerular filtration rate
GLC	Gas liquid chromatography
GlcNAc	*N*-Acetylglucosamine
GlcNAc	2-Acetamido-2-deoxy-glucopyranose
GlcNAc	N-Acetyl-D-glucosamine
GlcNAc T	*N*-Acetylglucosamine transferase
GlcNAc	2-Acetamido-2-deoxi-glucopyranose
GM-CSF	Granulocyte macrophage colony-stimulating factor
GNA	Galanthus nivalis agglutinin
GPI	Glycosylphosphatidylinositol anchor
GR	Glutathione reductase
GSH	Reduced glutathione
GSSG	Oxidized glutathione
GTN	Nitroglycerine
GTN	Glyceryl trinitrate

GVB	Gelatin veronal buffer
H_2O_2	Hydrogen peroxide
HA	Hemagglutination assay
Hb	Hemoglobin
HDL	High-density lipoprotein
HDL-Chol	HDL cholesterol
HDLs	High-density lipoproteins
HEPES	N-2-Hydroxyethyl piperazine-N′-2-ethanesulfonic acid
HGB	Haptoglobin
HGF	Hepatocyte growth factor
HLA	Human leukocyte antigen
HLA-DM	Human leukocyte antigen DM
Hp	Haptoglobin
HPA	Helix pomatia agglutinin
HPF	High-power field
HPT	Haptoglobin
HRP	Horseradish peroxidase
HSA	Human serum albumin
HSAP	Female protein of Syrian hamster
hsCRP	High-sensitivity C-reactive protein
HU	Hemagglutination unit
i.m.	Intramuscular
i.v.	Intravenous
I	Iodine
IBD	Inflammatory bowel disease
IC	Infected control
ICAM	Intercellular adhesion molecule
ICAM-1	Intercellular adhesion molecule 1
ICU	Intensive care unit
IEF	Isoelectric focusing
IFA	Indirect fluorescent antibody
IFN	Interferon
IFN-gamma	Interferon gamma
Ig	Immunoglobulin
IgE	Immunoglobulin E
IgG	Immunoglobulin G
IgM	Immunoglobulin M
IGT	Impaired glucose tolerance
IL	Interleukin
IL-1ra	IL-1 receptor antagonist
INF-γ	Interferon-γ
iNOS	Inducible nitric oxide synthase
IQR	Interquartile range
IRS1	Insulin receptor substrate 1
ITU	Intensive care unit
JAK/STAT	Janus kinase (JAK) and signal transducer and activator of transcription (STAT)
JVP	Jugular venous pressure

*K*a	Affinity constant
KA	Kala azar
kDa	Kilodalton
L. donovani	*Leishmania donovani*
L. rohita	*Labaeo rohita*
L	Lymphocyte
LBP	Lipopolysaccharide binding protein
LD body	*Leishmania donovani* body
LDH	Lactate dehydrogenase
LDL	Low-density lipoprotein
LIF	Leukemia inhibitory factor
LPA	Limulus polyphemus agglutinin
LPG	Lipophosphoglycan
LPS	Lipopolysaccharide
LTβR	Lymphotoxin-β receptor
LVH	Left ventricular hypertrophy
Ly-6G	Lymphocyte antigen 6 complex, locus G
M	Monocyte
MAA	*Maackia amurensis* agglutinin
mAb	Monoclonal antibody
MAC	Membrane attack complex
Mal	Malaria
MALDI	Matrix-assisted laser desorption ionization
MALDI-TOF	Matrix-assisted laser desorption ionization time of flight
MAP kinase	Mitogen-activated protein kinase
MASP	MBL-associated serine protease
MBL/MBP	Mannose-binding lectin/protein
MBL	Mannose-binding lectin
MBP	Mannose-binding proteins
MBP	Myelin basic protein
MCP	Metacarpophalangeal
MCP-1	Monocyte chemoattractant protein-1
MCV	Mean corpuscular volume
MDA	Malondialdehyde
mDC	Myeloid dendritic cell
MDR	Multidrug resistant
mEq	Milliequivalents
MET	Metformin
MFI	Mean fluorescence intensity
mg	Milligram
MHC	Major histocompatibility complex
MI	Myocardial infarction
MIP1a	Macrophage inflammatory protein-1 alpha
MIP1b	Macrophage inflammatory protein-1 beta
miR	Micro-ribonucleic acid
MMP	Matrix metalloproteinase
Mol. Wt	Molecular weight

MP	Microparticle
mPCa	Metastatic prostate cancers
MPs	Microparticles
MRI	Magnetic resonance imaging
mRNA	Messenger ribonucleic acid
MS	Mass spectroscopy
MSC	Mucosal stem cell
MSCs	Mesenchymal stem cells
MSP	Modified seminal plasma
MW	Molecular weight
N	Neutrophil
NA	Not applicable
NaCl	Sodium chloride
NADPH	Nicotinamide adenine dinucleotide phosphate hydrogen
NAPI	Nutritional and acute-phase indicator
NCQ	Nanochloroquine
ND	Not determined
Neu5,9Ac_2	9-O-Acetylneuraminic acid
Neu5Ac	Neuraminic acid
NF-κβ	Nuclear factor kappa-light-chain-enhancer of activated B cells
NF	Nuclear factor
NF-L	Neurofilament light chain
NHS	Normal human serum
NK cells	Natural killer cells
NM	Non-malarial
NO	Nitrogen oxide
NO	Nitric oxide
NOS	NO synthase
OD	Optical density
O-AcSA	O-acetyl sialic acid
O-AcSG	O-acetyl sialoglycoconjugate
°F	Degree Fahrenheit
O-GalNAc	O-N-Acetylgalactosamine
O-GlcNAc	O-N-Acetylglucosamine
OGT	GlcNAc transferase
OPD	O-diamisidine
OS	Osteogenic sarcoma
OSA	Obstructive sleep apnea
OSM	Oncostatin M
oxLDL	Oxidized low-density lipoprotein
p65	Transcription factor p65 also known as nuclear factor NF-kappa-B p65 subunit
PAF	Platelet-activating factor
PAGE	Polyacrylamide gel electrophoresis
PAI	Plasminogen activator inhibitor
PAI-1	Plasminogen activator inhibitor type 1

PAMPs	Pathogen-associated molecular patterns
PAP	Pulmonary artery pressure
PB	Phosphate buffer
PBL	Peripheral blood lymphocytes
PBMC	Peripheral blood mononuclear cells
PBMs	Peripheral blood-derived macrophages
PBS	Phosphate-buffered saline
PC	Phosphorylcholine
PCa	Prostate cancers
PCT	Procalcitonin
PTCA	Percutaneous transvenous coronary angiography
pDC	Plasmacytoid dendritic cell
PDGF	Platelet-derived growth factor
PE	Phosphoethanolamine
PEF	Peak expiratory flow
PET	Positron emission tomography
Pf	*Plasmodium falciparum*
pg	Pictogram
PGN	Peptidoglycan
PI	Propidium iodide
pI	Isoelectric point
PINI	Prognostic inflammatory and nutritional index
PKDL	Post-kala-azar dermal leishmaniasis
PLA_2	Phospholipase enzyme
PMA	Phorbol myristate acetate
PMN elastase	Polymorphonuclear elastase
PNA	Peanut agglutinin
PON1	Paraoxonase
PRE	Prealbumin
pro-BNP	Pro-brain natriuretic peptide
PRRs	Pattern recognition receptors
PSA	Prostate-specific antigens
PSD	Post-source decay
PTT	Prothrombin time test
PTX3	Pentraxin 3
PUFA	Polyunsaturated fatty acids
pz complex	Properdin–zymosan complex
RA	Rheumatoid arthritis
RAGEs	Receptor for advanced glycation endproducts
RBBB	Right bundle branch block
RBC	Red blood cells
RBC-CRP complex	RBC were complexed with CRPMal
RBC_{Mal}	Erythrocytes from malaria
RBC_N	Erythrocytes from normal individual
RBP	Retinol binding protein
RBS	Random blood sugar
RCA	*Ricinus communis* agglutinin

Rf	Rate of front mobility
RNA	Ribonucleic acid
RNI	Nitrogen intermediates
ROS	Reactive oxygen species
rRAP-1	*Plasmodium falciparum* rhoptry-associated protein-1
RT-PCR	Reverse transcription polymerase chain reaction
RWMA	Resting wall motion abnormality
S.D	Standard deviation
S_1	First heart sound
S_2	Second heart sound
SA	Sialic acid
SAA	Serum amyloid A
SAG	Sodium antimony gluconate
SAP	Serum amyloid P component
sCr	Serum creatinine
SD	Standard deviation
SDS	Sodium dodecyl sulfate
SDS-PAGE	Sodium dodecyl sulfate polyacrylamide
SEM	Standard error of mean
SEM	Scanning electron microscopy
SGOT	Serum glutamate-oxalate transaminase
SGPT	Serum glutamate pyruvate transaminase
SialT	Sialyltransferases
SLE	Systemic lupus erythematosus
SLED	Sustained low-efficiency dialysis
SMA	Severe malarial anemia
SNA	*Sambucus nigra* agglutinin
SNPs	Single-nucleotide polymorphisms
snRNPs	Small nuclear ribonucleoprotein particles
SOS	As and when required
SP-D	Surfactant protein-D
$sPLA_2$	Secretory phospholipase A_2
$sPLA_2$-IIA	Secreted group IIA phospholipase A_2
SpO_2	Peripheral capillary oxygen saturation
SPR	Surface plasmon resonance
SSM	Sheep submaxillary mucin
ST	The ST segment represents the period when the ventricles are depolarized in ECG
STAT	Signal transducers and activators of transcription
STAT3	Signal transducer and activator of transcription 3
sTNFR75	Soluble receptor for TNF alpha
T2D	Type 2 diabetes mellitus
TAP	Transporter associated with antigen processing 1

TB	Tuberculosis
TBA	Thiobutiric acid
TBARS	Thiobarbituric acid reactive substance
TBS	Tris-buffered saline
TCA	Trichloroacetic acid
TCR	T-cell receptor
TEC	Tubular epithelial cells
TEMED	N,N,N′,N′-Tetrameth-ylethylenediamine
TFA	Trifluoroacetic acid
TfR	Soluble transferrin receptors
TfR	Transferrin receptor
TGF-β	Transforming growth factor beta
T_H cell	T helper cell
TIBC	Total iron-binding capacity
TLC	Thin-layer chromatography
TLC	Total leukocyte count
TLR	Toll-like receptors
TMCS	Trimethylchlorosilane
TMS	Trimethylsilyl
TNF	Tumor necrosis factor
TOF	Time of flight
TRF	Transferrin
TSST-1	Toxic shock syndrome toxin-1
TTR	Transthyretin
UC	Ulcerative colitis
uCRP	Urinary CRP
UEA	*Ulex europaeus* agglutinin
USG	Ultrasonography
VAP	Ventilator-associated pneumonia
VCAM	Vascular cell adhesion molecule
VCAM-1	Vascular adhesion molecule-1
VEGF	Vascular endothelial growth factor
VFD	Ventilator-free days
VIP	Vasoactive intestinal peptide
VL	Visceral leishmaniasis
VL	Visceral leishmaniasis
VLDL	Very low-density lipoprotein
VPF	Vascular permeability factor
vWF	Von Willebrand factor
WBC	White blood corpuscles
WGA	Triticum vulgaris agglutinin
WHO	World Health Organization
WNL	Within normal limit
WT	Wild type
Zn	Zinc
ZPP	Zinc protoporphyrin