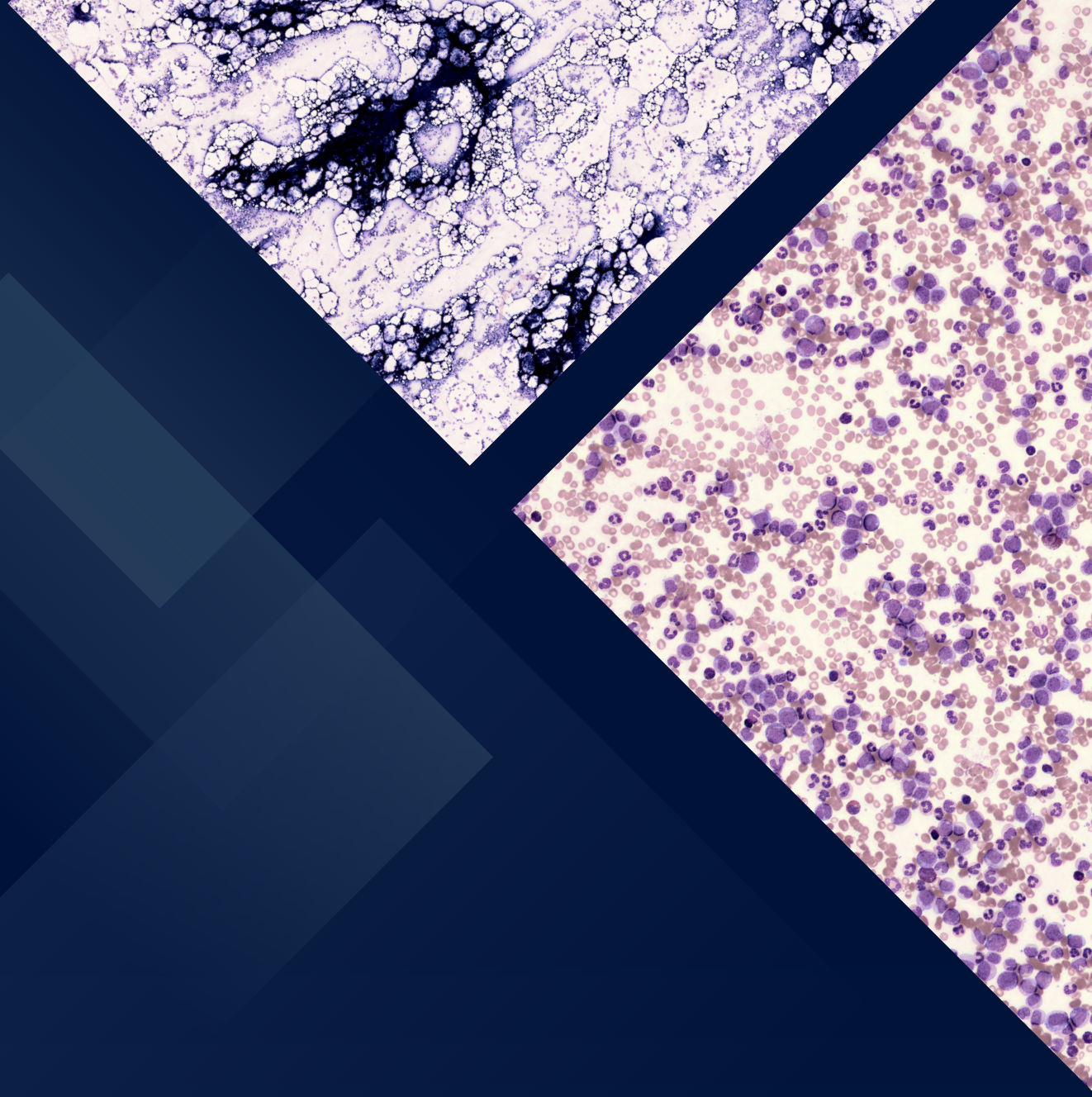


Digital hematology in focus:

The clinical impact of Full-Field technology

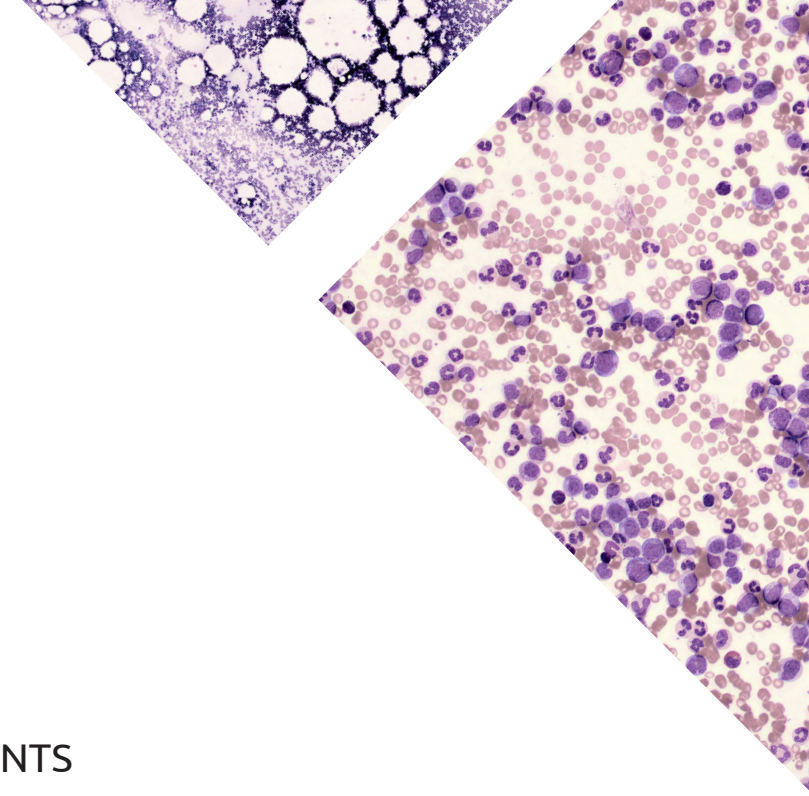
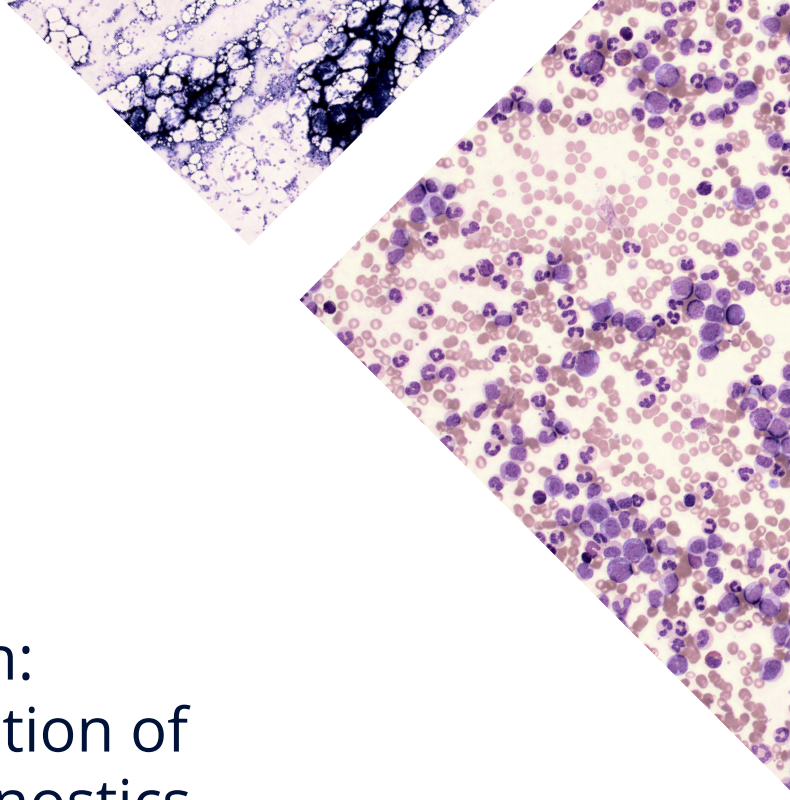


TABLE OF CONTENTS



Introduction: The last bastion of analog diagnostics

Digital morphology innovation is transforming the future of diagnostics; opening the door to earlier detection and accurate diagnoses of cancers, infections, and other diseases; and improving both patient care and the patient experience.

Blood tests remain one of the most accessible, rapid, and reliable methods in the diagnostic workup, and the CBC is one of the most common, with an estimated 500M performed annually in the US.[1, 2, 3, 4]

Today's automated CBC analyzers are consistent, easy-to-use, and versatile – able to perform three-, five- or six-part differentials with reliable results. However, when abnormal counts or findings are flagged by these automated analyzers, a peripheral blood smear (PBS) is performed in about 10-20% of cases.[1] The PBS is reviewed by a laboratory scientist, hematologist, or hematopathologist for more thorough evaluation.

These reviews are predominantly conducted manually by an expert looking at a sample under a microscope. The expert will manually classify and count cells by type and look for abnormalities that could signify cancer, infection, inflammation, or disease. Blood smear review serves to ensure that no clinically significant finding is missed and provides important diagnostic clues.[3,5,6]

Despite its importance, PBS review has seen little innovation over the years. It remains reliant on analog technology because no technology until now has been able to eliminate the trade off between the resolution needed to view small morphological details of cells and the ability to view the slide in its full context through a full field of view. In addition, manual PBS continues to be a time- and resource-intensive process,[7] creating a costly problem in the clinical laboratory that impacts workflow efficiency.[1, 6, 8]

This eBook examines the challenges facing hematology laboratories and the unprecedented technological advances that finally offer solutions. In particular, we look at the emergence of full-field digital technologies that are making manual PBS reviews obsolete, making laboratories more efficient, and empowering laboratory staff and morphologists to do more in less time, remotely as necessary, and with greater confidence and consistency.

> “ Depending on the patient population, **10-20%** of all slides may require manual review.”[1]

Manual microscopy in hematology

When the CBC result is flagged, a blood smear must be examined under a microscope by a trained user.[1]

When is an automated CBC referred for a manual review?

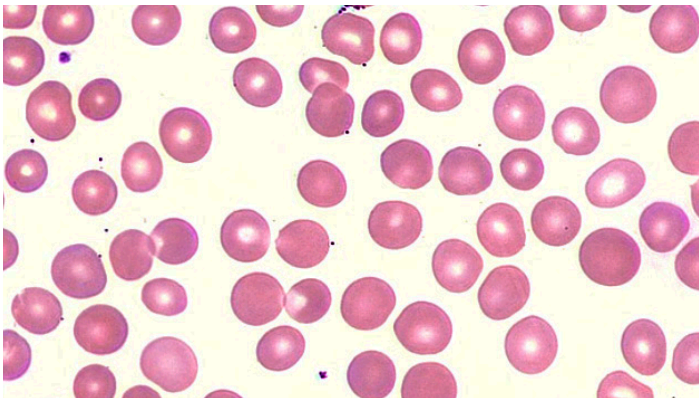
- Unexpectedly high or low blood cell counts[3]
- When the instrument flags anomalies with red blood cell, platelet, or white blood cell morphology[3]
- When the instrument flags an abnormal white blood cell differential[3]

The peripheral blood smear (PBS)

> “While in general we have four vital signs, in hematology, examining the peripheral blood smear is the fifth one. Similar to the role of other vital signs, a normal peripheral blood smear is as helpful as an abnormal one in the journey to establishing a diagnosis.”
>
> **Samer Al Hadidi, MD, MS, FACP[9]**

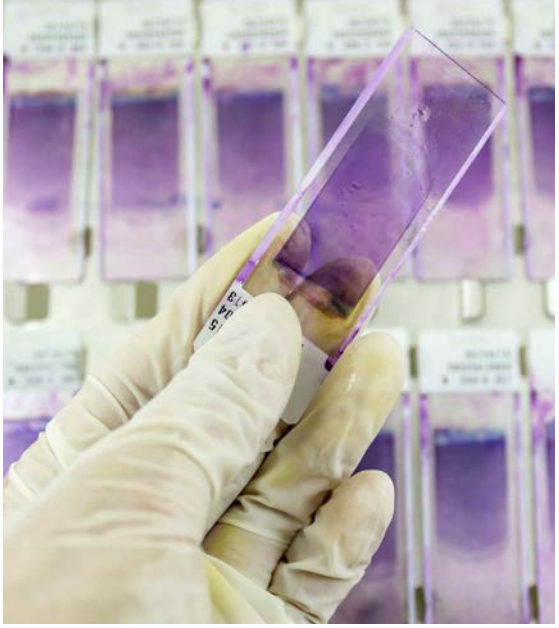
Clinical laboratory test results are essential in approximately 70% of clinical decisions and are requested in roughly 30% to 40% of all primary care appointments.[10]

From a morphological standpoint, examination of a PBS provides a fairly comprehensive hematologic assessment. A meticulous review of the blood smear is crucial for identifying diagnostic clues and capturing all clinically relevant findings. Additionally, PBS review enables the morphological diagnosis of diverse primary and secondary blood-related diseases and disorders.[3, 11]

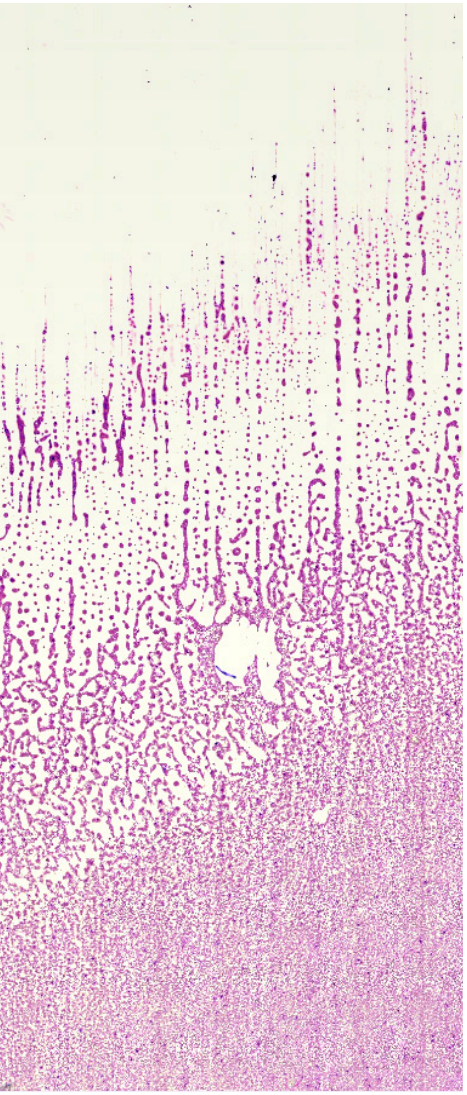


In addition to serving as a confirmatory test for the CBC, PBS review may also be requested by the physician. Clinical indications for a blood smear review request include:[3]

- **Unexplained anemia (low red blood cell (RBC) count), thrombocytopenia (low platelet count) and/or leukopenia (low white blood cell (WBC) count)**
- **Suspicion of microangiopathic hemolytic anemia (e.g., thrombotic thrombocytopenic purpura, disseminated intravascular coagulation, etc.)**
- **Hemoglobinopathy (e.g., sickle cell anemia, hemoglobin C disease (SC), and the sickle β-thalassemia)**
- **Red cell membranopathy (e.g., hereditary elliptocytosis, hereditary spherocytosis, etc.)**
- **Lymphoproliferative disorder, plasma cell dyscrasia, myeloproliferative disorder, myelodysplastic syndrome**
- **Parasitic infection, infectious mononucleosis**
- **Inherited leukocyte disorder (e.g., Pelger-Huet, May-Hegglin, etc.)**
- **Inherited platelet disorder (e.g., gray platelet syndrome).**



Obtaining full value from a blood smear examination requires a well-prepared, well-stained blood smear that incorporates the monolayer, the body and base of the smear, and the feathered edge.[12]



The monolayer

Typically, this region is situated approximately one 10X field behind the feathered edge and represents the ideal area for cell morphology examination. This area is preferred because it dries rapidly, resulting in well-spread cells that are not overlapping or disturbed. Within this section, RBCs exhibit separation or minimal overlap, and WBCs should be evenly distributed.[12]

The body and base of the smear

(sometimes referred to as the thick or stacked area)

These regions are generally too thick for a thorough examination under higher magnification. The thickness of the smear in this area prevents the rapid drying required for leukocytes to spread adequately. As a result, WBCs in this region appear shrunken and significantly smaller compared to the quickly dried sections, making it challenging to distinguish individual leukocytes.[12]

The feathered edge

(sometimes referred to as the thin area – is where the cells are spread out amid large empty spaces)

The feathered edge should be the initial focus of examination to detect platelet clumping, microfilaria, certain RBC anomalies, and large neoplastic cells. Abnormally large cells, which could hold diagnostic significance, often cluster toward the feathered edge.[12]

Careful evaluation is essential for assessing the distribution, size, shape, color, cellular inclusions, and morphology of the other major cell lines.[11]

Drawbacks of manual PBS review

> “Digital hematopathology… paves the way for computational photography and artificial intelligence to transform diagnostic assessment from being qualitative (relying on subjective assessment by a hematologist or hematopathologist) to quantitative through image analysis.”
>
> **Amit (Amy) Meitus, MD,**
> Chief Product Officer
> at Scopio Labs

Microscopy offers the advantage of 100X magnification, allowing trained users to observe intracellular details. However, manual approaches to hematologic laboratory diagnostics are limited in their ability to provide a comprehensive understanding of the underlying disease or condition.[6]

A limited field of view reveals only a small portion of the slide at a time, potentially excluding rare events or abnormalities.

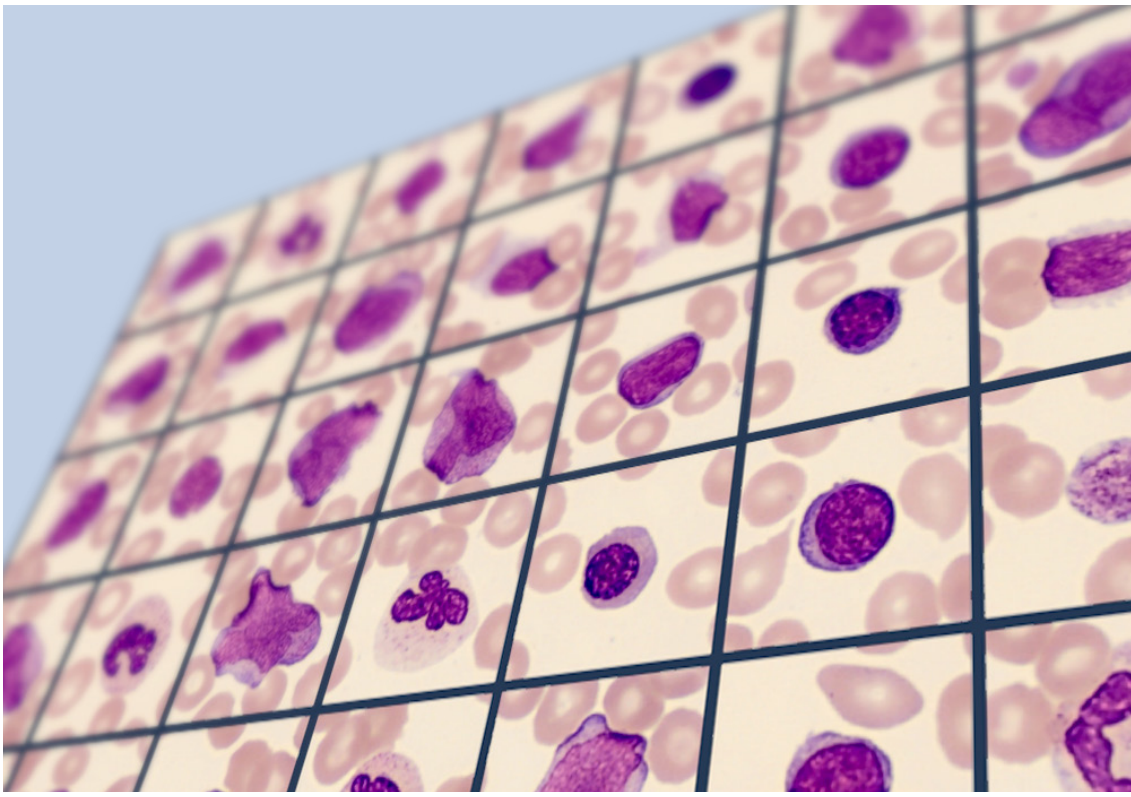
There are other notable drawbacks as well:[1, 5, 13]

- **The manual PBS is labor-intensive and time-consuming**
- **There is risk of human error due to a lack of focus, fatigue, or inexperience**
- **Conclusions are subjective and dependent on the experience of the user, resulting in inter-operator variability and poor repeatability**
- **Samples are not easily shared and must be physically transported for review, or reviewers must come to the lab, which slows the diagnostic process**
- **The manual PBS relies on the physical presence of laboratory professionals, limiting remote work capabilities and in some cases delaying diagnosis.[6]**

Turnaround time (TAT) is one of the best metrics for laboratory performance and is defined as the time from receipt of the sample in the laboratory to final dispatch of the corresponding test report.[14]

On average, the process of analyzing morphological findings and generating a written report with a summary of the findings for each PBS review takes approximately 10–15 minutes.[10]

> “Current digital morphology of blood smears is not really fully digital, and the main reason is the narrow field of view.”
>
> **Dr. Benzi Katz, PhD,** Senior Lecturer, Sackler Faculty of Medicine, Tel Aviv University, and Director, Hematology Lab, Tel Aviv Medical Center (Ichilov).



Partial digitization and the rise of cell-locating technology

Given the limitations of manual microscopy, laboratory medicine adopted cell-locating technologies that captured digital images of blood smears, allowing for digital sharing and remote analysis.[1]

However, conventional digital cell-locating technology provided only a partial solution to the bottleneck of manual microscopy. It provides only snapshots of individual cells, but not in the context of the sample’s clinically relevant area.

This limited field of view (FOV) is problematic for the laboratory scientist and physician, who typically want to see the full context of the slide to get an overall impression and then zoom in on cells or areas of interest. Understanding the clinical context surrounding a blood sample is essential to diagnosis.

Limited FOVs tether hematology to the microscope

> “What’s needed is a digital solution that more closely replicates the full-field experience of using a manual microscope, yet with all the advantages of digital image capture, analysis, sharing, storage, and full remote access.”[8]

Due to the limitations of cell-locating systems, they are still generally used only as a preliminary screening method. Additional manual microscopic examination is still required for abnormal samples.[8]

This is particularly relevant for:[1]

- **Patients with leukemia**
- **All newborns**
- **When there is suspicion of pathological cell types, blasts, plasma cells, and immature granulocytes**
- **Suspected schistocytes (fragmented part of an RBC)**
- **Dysplastic cells (highly variable in size and shape, with increased pigmentation, staining or color)**
- **Intracellular parasites (e.g., malaria)**
- **Platelet clumps.**

With clinical laboratories facing staffing shortages, increased demand for testing, and budgetary limitations,[15, 16] this inefficient workflow and the trade-off between FOV and resolution it requires is unsustainable.

Getting to the big picture:

Introducing
Full-Field imaging

Full-field digital cell morphology is a novel digital approach to imaging that utilizes computational photography to capture the full context of a PBS sample and the intracellular details at the same time. Its emergence provides a no-compromises alternative to manual microscopy and digital cell-locating systems.

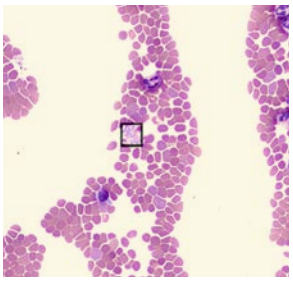
A Full-Field digital image represents an automated selection of the optimal area for PBS morphology review. It includes the top of the thick area of the sample, the monolayer, and the feathered edge. Each scan equates to at least 1,000 fields of view at 100X oil immersion resolution equivalent, and the technology automatically adapts to long or short smears.

What is Full-Field Imaging?

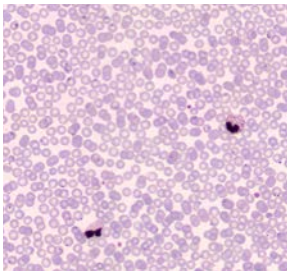
> “The revolutionary full-field capability of the system includes the monolayer and feathered edge, which enables experts to gain the general slide context that is critical for proper clinical decision making.”[8]

Full-Field imaging...

- Enables lab experts to view cells at **100X** oil immersion resolution equivalent without losing sight of the larger sample context.
- Solves the tradeoff between FOV and resolution, dramatically reducing reliance on manual processes in the lab.
- Provides a complete digital version of the slide, emulating the experience of manual microscopy.
- Offers accurate estimations of cells that have uneven distribution. When you have one or few abnormal cells (such as plasma cells or immature granulocytes), their significance is more obvious when viewed in context and when additional areas of the sample can be reviewed. For example, with full-field images, clumps were detected in the feathered edge in 100% of confirmed pseudothrombocytopenia cases.[8]



Platelet clumps



Malaria

Streamlining workflows

In addition to excellent clinical performance, full-field PBS technology offers operational advantages as well, by:

- **Reducing TAT by half**
- **Substantially reduced workloads**
- **Increasing workflow efficiency by 60%**
- **Improving repeatability and reproducibility**

> “Under clinical study settings, where each examiner reported on a 200-WBC differential, complete RBC morphology evaluation and platelet estimation based on 10 FOVs, the median time for manual review was **20:00** minutes per case, and the median time for Scopio’s Full-Field PBS review was **7:46** minutes, a 60% improvement of workflow efficiency.”[8]

Enabling fully remote workflows

Unlike cell-location technology, full-field cell morphology enables professional interactions to take place fully remotely, facilitating secure consultation and collaboration across widely distributed sites.

Fully digital workflows dissolve the physical boundaries of the clinical laboratory, paving the way for a new kind of remote workplace* that benefits patient outcomes and optimizes lab operations.

Only full-field technology provides a remote reviewer with both the full context of the PBS and the ability to zoom in on any cell or group of cells at 100X magnification. The monolayer and feathered edge are all within view and the reviewer can examine any detail, anywhere on the scan. Hospital and lab networks can now operate seamlessly and securely across multiple facilities. This allows for more efficient workload balancing and fully remote consultations that can help alleviate personnel shortages and burnout.

In addition, full-field technology offers the ability to annotate and reference cells, which is essential to efficient remote workflows and fast treatment decisions. For example, M3 acute myeloid leukemia can be treated easily if the diagnosis comes very early, and morphology is the fastest test. When the technician can annotate the image, the physician can see the referenced cells immediately, speeding diagnosis.

> “Looking back on the two years we’ve been using the full-field digital system, I can think of only a handful of cases where I’ve had to revert to a manual review, usually in cases where the specimen is technically problematic.”

Dr. Benzi Katz, PhD,
Senior Lecturer, Sackler Faculty of Medicine, Tel Aviv University, and Director, Hematology Lab, Tel Aviv Medical Center (Ichilov).

One and done. Without the microscope

Full-Field imaging enables confident, comprehensive, and consistent remote analysis through the secure hospital network from anywhere. As a result, there is no need for trips to the lab for redundant manual confirmation.

For example, common conditions such as pseudothrombocytopenia and the presence of malignant cells may not be properly assessed with cell-locating technology, because the scanned FOV is too narrow. This prompts the reviewer to conduct a manual microscopic review. Full-field technology, on the other hand, provides all the information for accurate diagnosis in the initial scanned image.

Augmenting expertise with AI

Advancements in AI are helping laboratories realize the full potential of full-field digital imaging. Scopio’s full-field technology combines high-resolution imaging with a powerful AI-driven decision support system that speeds interpretation and reporting by automating cell detection, pre-classification, and quantification for the lab scientist.

The Scopio AI decision support system leverages a state-of-the-art Adaptive Monolayer Detection algorithm designed to identify the clinically relevant area and adapt for optimal review.

It then performs WBC detection and provides suggested pre-classification into 14 classes. The **RBC AI-DSS analyzes over 10,000 cells across 1,000 fields of view (FOV) and pre-grades 22 RBC morphological parameters. Finally, the AI-DSS identifies platelets and provides a pre estimation from 10 fields of view, including automated platelet clump detection throughout the scanned area and the feathered edge, at an unprecedented 100x oil-immersion resolution-equivalent for every scan. Expert reviewers can view both large and small platelet clumps at the feathered edge and in the monolayer, always in context.

CASE STUDY #1

What the data says about performance

A study of 645 PBS samples offers a look at the superior performance of Full-Field technology vs. traditional manual microscopic review.[8]

- **Reference** = manual microscopy
- **Test** = Full-Field digital imaging

Three centers participated in the study:[8]

- Division of hematology in Tel Aviv, Sourasky Medical Center
- Department of pathology at University of Pennsylvania
- Department of Pathology at Brigham and Women's Hospital

Results:[8]

- Excellent repeatability and reproducibility for WBC
- Excellent precision for neutrophils, lymphocytes, monocytes, and eosinophils
- Comparable WBC normal ranges, regardless of the methodology used
- Excellent correlation between morphologic analysis, which was performed under the microscope or on screen
- Excellent accuracy between CBC manual and automated estimation

Accuracy rate for morphological abnormalities:

96.82%

•

Total accuracy for WBC analysis

96.29%

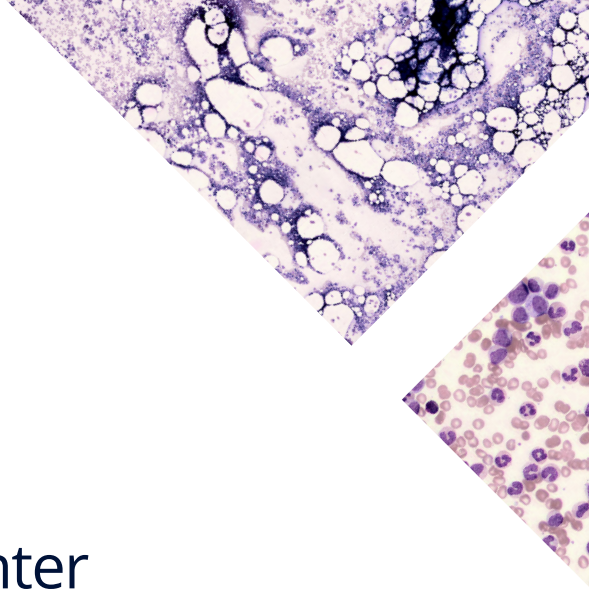
•

Scopio's Full-Field PBS WBC accuracy evaluation:

Efficiency: 96.29%

Sensitivity: 87.86%

Specificity: 97.62%



CASE STUDY #2

Tel Aviv Medical Center

About Tel Aviv Medical Center

- 1,500 beds
- 400,000 inpatients
- Large hematology department
- Hematooncology inpatient, day patient, and outpatient services
- Routine laboratory lab (CBC, basic coagulation, and morphology services)
- Other labs: flow cytometry, specialty coagulation, immunohematology lab, stem cell processing unit, and molecular biology lab

Tel Aviv Medical Center strives to stay at the forefront of clinical excellence and diagnostic efficiency. In [2005], it became the first hospital in Israel to convert from manual-only microscopy to digital cell locating technology. As a result, the lab went from conducting approximately 25 full differentials per technician per day to an average of 35 per technician per day, creating a significant improvement in TAT.

However, in about 40% of cases, the lab still had to revert to manual microscopy. In cases such as suspected thrombocytopenia, low blood count analysis, and leukopenic samples, looking at a limited area of the slide could lead to misinterpretation of the morphology. So, while the lab was benefiting from digital technology, technicians were still relying heavily on manual workflows.

Results:

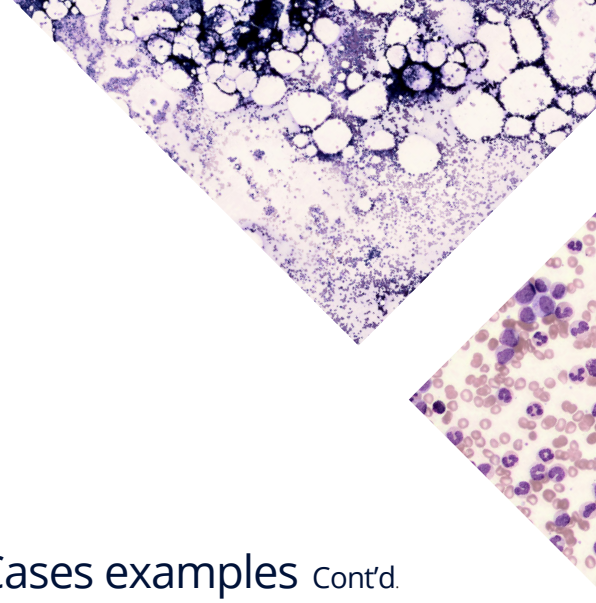
In 2021, the lab implemented Full-field technology using Scopio's Full-Field PBS application, with dramatic results.

- **Capacity rose to 50 full differentials per day per technician**
- **Standardization and consistency improved**
- **PBS results were delivered faster**
- **TAT improved over weekends due to remote workflows**

Cases examples:

In the following cases, Full-Field imaging provided essential visibility of clinically significant areas of the PBS. In each instance, the review was conducted remotely during weekend hours when the pathologist was off-site.

Full-field imaging provides the ability to look at the correct position on the slide and visualize the target cells, ovalocytes, echinocytes, acanthocytes, and cell fragments required to diagnose TTP.



CASE STUDY #2

Tel Aviv Medical Center | Cases examples Cont'd.

> "The ability to view and interpret cases fully remotely, without having to revert to manual microscopy review, combined with the convenience of being able to review these cases over the weekend, significantly and positively impacted the weekday workflow. This resulted in cost savings through the saving of additional weekday shifts to compensate for the weekend caseload backlog."[6]

Dr. Benzi Katz, PhD,
Senior Lecturer, Sackler Faculty of Medicine, Tel Aviv University, and Director, Hematology Lab, Tel Aviv Medical Center (Ichilov).

Non-Hodgkin's Lymphoma [Caption for non-Hodgkin's Lymphoma]
This slide was prepared and scanned with a viral infection suspected. However, full-field imaging revealed cleaved cells, some of which resembled blasts. Flow cytometry confirmed non-Hodgkin lymphoma.

Acute Myeloid Leukemia [Caption for acute myeloid leukemia]
Eosinophils are visible, as are an uneven distribution of granules in the cytoplasm, teardrop cells, and hypergranulation in Perger-like cells. Elsewhere in the slide, other abnormalities are visible, including giant platelets and blasts. A bone marrow aspiration confirmed acute myeloid leukemia and a background of myeloproliferative neoplasm.

Morphology TAT the hematology laboratory

dropped 15.8%

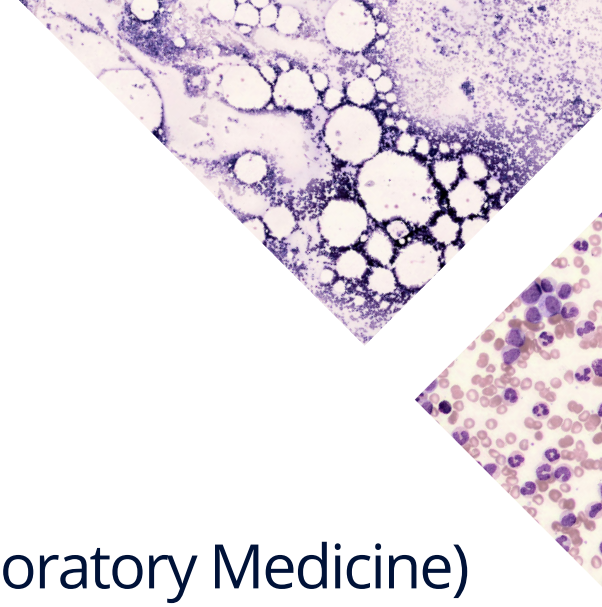
overall due to remote review of PBS using the Full-Field PBS Scopio application. The reduction was most significant over the weekend, with a

41.4% reduction

in TAT on the first day of the weekend and

59.1% reduction

on the first weekday.[6]



CASE STUDY #3

ZLM (Center for Laboratory Medicine)

ZENTRUM FÜR
LABORMEDIZIN

About ZLM

- ZLM offers 24-hour medical laboratory services to institutions including public and private hospitals, independent physicians, and university hospitals across Switzerland.
- ZLM's main lab is located at the cantonal hospital in St. Gallen, and it operates five additional satellite locations.
- Its hematology department specializes in morphology, flow cytometry, hemostasis, and immunohematology.

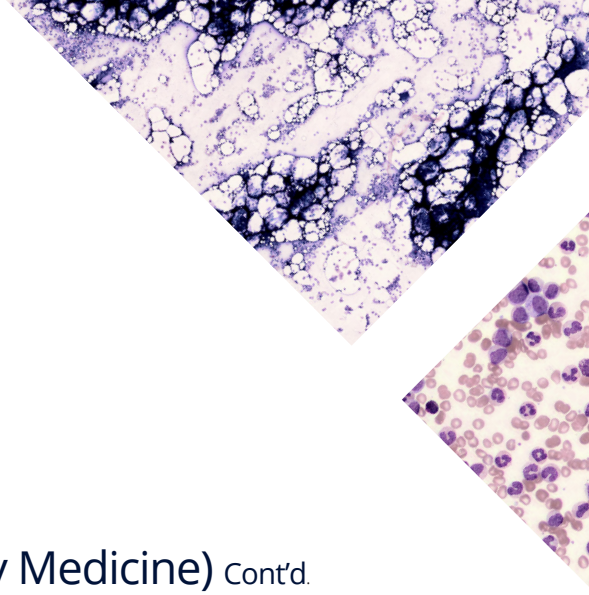
Like hematology labs around the world, the Center for Laboratory Medicine (ZLM) faces rising demand for its services alongside ongoing staffing shortages. Morphology analysis was a particular productivity drain for ZLM facilities.

ZLM was looking for an automated digital solution that would make the process faster and more efficientat its six locations in Switzerland.

To evaluate Scopio's technology, ZLM conducted a formal and objective reference-based test. They performed morphology analysis on 50 PBS samples, comparing manual microscopy against the Scopio X100 with Full-Field Peripheral Blood Smear Application. The goal was to determine whether the Scopio system could partially or fully replace manual microscopy and provide a more efficient, consistent, and remote-accessible method for PBS analysis.

Results:

- **High degree of correlation for neutrophils, lymphocytes, monocytes, eosinophils, and platelets between Scopio and manual microscopy**
- **Comparable correlation for the morphological analysis of platelets and RBCs**
- **Agreement between the test and reference method for RBC morphology of 99.77%**
- **Accuracy for platelet estimation resulted in an efficiency of 94.89%, sensitivity of 90.00%, and specificity of 96.28%, with successful R&R tests**
- **Overall satisfaction rate of about 90% for end users**
- **57% reduction in turnaround time for PBS at St. Gallen's hub lab vs manual microscopy**
- **WBC accuracy with an efficiency of 96.29%, sensitivity of 87.86%, and specificity of 97.62%.**

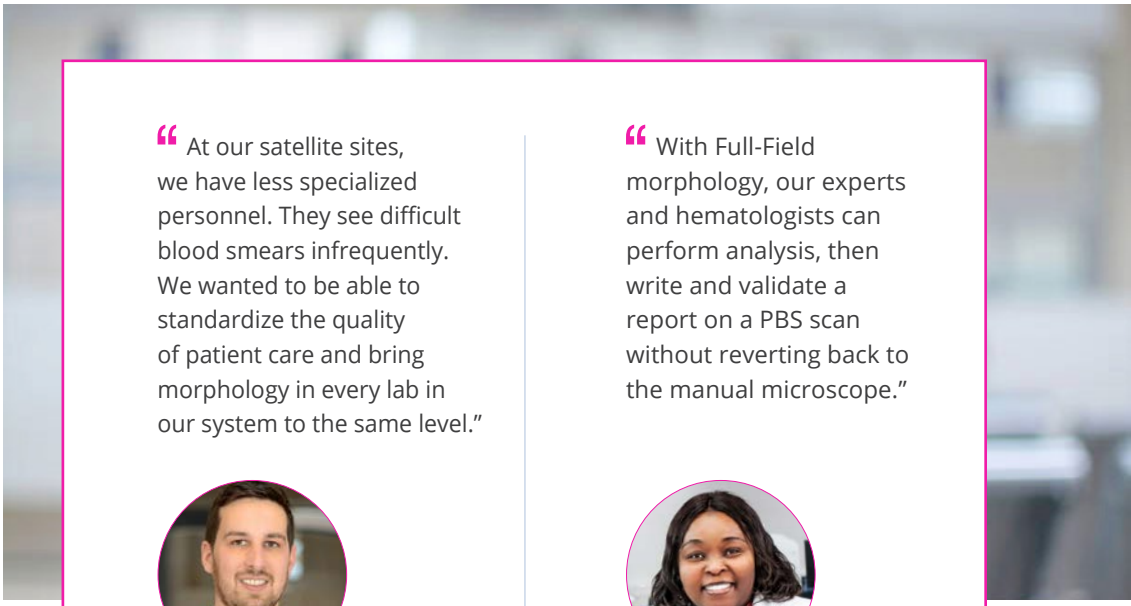


CASE STUDY #3

ZLM (Center for Laboratory Medicine) Cont'd.

ZLM's rigorous evaluation of Scopio's full-field high resolution imaging and built-in AI driven decision support system showed that Scopio could deliver on the lab network's key goals.

ZLM has since deployed the Scopio X100HT at the central lab and three X100 devices at its satellite locations. By enabling a fully digital workflow around the clock, full-field images can now be reviewed digitally from anywhere, immediately. Reviewers can access complete information and thus don't have to return to the microscope before making a report for clinicians.



"At our satellite sites, we have less specialized personnel. They see difficult blood smears infrequently. We wanted to be able to standardize the quality of patient care and bring morphology in every lab in our system to the same level."

Dr. Lukas Graf

Head of Department of Clinical Chemistry, Hematology, Immunology; Consultant Hematologist at ZLM

"With Full-Field morphology, our experts and hematologists can perform analysis, then write and validate a report on a PBS scan without reverting back to the manual microscope."

Joyce Richardson

Senior Consultant for Morphology and Immunohematology, Division of Hematology at ZLM

Conclusion

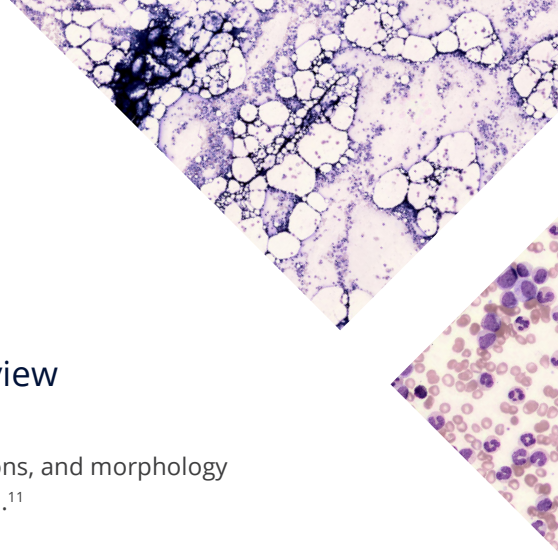
For more information on the Full-Field Peripheral Blood Smear Application, visit us at scopiolabs.com

Scopio has developed a Full-Field digital imaging platform using novel computational photography and clinical-grade AI that automatically analyzes blood samples at the highest resolution available and in minutes. We have secured FDA clearance for our Full-Field Peripheral Blood Smear Application, and Scopio technology is in commercial use at hospitals and labs in the US, Europe, and Israel.

Our Full-Field technology represents a fundamental change in laboratory medicine with enormous clinical and operational implications. By empowering experts to digitally and remotely assess the general context of a sample, zoom in on the smallest details of a single cell, and leverage AI to augment decision making, Full-Field technology is transforming how, where, and how efficiently accurate diagnosis can take place.

Most important, Full-Field innovation enables faster, earlier detection and diagnosis of blood-related diseases, so patients can start treatment sooner and have better outcomes. It is a life-saving technology whose time has come.

Scopio



APPENDIX

A closer look at triggers for PBS review

The distribution, size, shape, color, cellular inclusions, and morphology of the major cell lines should be carefully assessed.[11]

White cell morphology

Abnormalities in leukocyte morphology can hold the diagnostic clue to various underlying pathologies. A rapid evaluation of cell counts is possible, with a typical range of approximately 2 to 5 leukocytes observed per high power field (HPF). Generally, each leukocyte counted per HPF approximates roughly 200 cells in peripheral blood when using a 10X objective lens and around 2000 cells when using a 100 X objective lens. The more cells included in the count, the more accurate the estimate becomes. Therefore, estimating leukocyte cell counts is more reliable when done at low power, particularly in cases with low WBC counts (leucopenic specimens). A manual review of automated counts with peripheral blood film should be performed when flagging occurs due to excess counts.[11]

Triggers for further evaluation include:[17]

- **High (>20 x 103/µL) or low (<4 x 103/µL)**

Abnormally large cells, which could hold diagnostic significance, tend to migrate toward the smear's feathered edge.[12] For instance, Epstein-Barr virus (infectious mononucleosis), can result in the presence of large, irregular lymphocytes.[18] Infections like Bordetella pertussis (whooping cough) can lead to smaller lymphocytes.[18, 19]

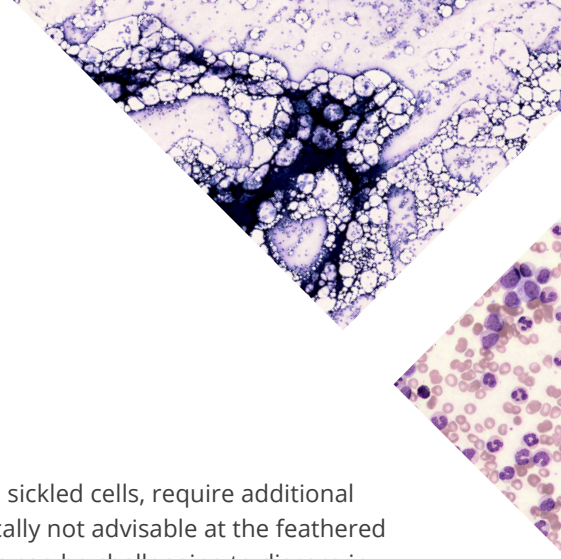
In cases of malignant conditions such as Chronic Lymphoid Leukemia (CLL) and Acute Myeloid Leukemia (AML), WBCs may accumulate at the feathered edge. These cells may exhibit a less random distribution, potentially leading to their oversight in a manual slide review that does not include an assessment of the feathered edge.[17]

Red cell morphology

The typical RBC possesses a distinctive biconcave disc shape, measuring approximately 7–8 µm in diameter. It features central pallor, which accounts for about one-third of the red cell's diameter and is devoid of any intracytoplasmic inclusions. When stained with Romanowsky dye, RBCs appear pink in color due to the interaction between hemoglobin and eosin, the acidophilic components of the dye. Any deviations from the norm, such as variations in cell size, shape, color, the presence of intracellular inclusions, or irregular cell arrangement, can indicate a wide range of abnormalities.[11]

Triggers for further evaluation include:[17]

- **Hemoglobin levels <7 gr/dL or >18 gr/dL**
- **Reticulocytes >0.100/µL**
- **MCV <75 fL or >105 fL**



APPENDIX Cont'd.

Qualitative disorders, such as dimorphic RBCs and sickled cells, require additional scrutiny. Studying normal RBC morphology is typically not advisable at the feathered edge of the blood smear, as abnormal cell features can be challenging to discern in this area.[20] However, the feathered edge serves as an ideal location for observing RBC abnormalities like Howell-Jolly bodies (fragments of DNA and typically seen in the peripheral smears of individuals with sickle cell disease following auto-splenectomy) and Pappenheimer bodies (abnormal granules of iron found inside RBCs on a routine blood stain.),[21] identifying the presence of rouleaux (stacked cells), and detecting internal cell parasites.[17]

Platelet morphology

Platelets, also known as thrombocytes, typically measure around 2-4 by 0.5 microns in size, which is roughly one-third of the diameter of a normal-sized RBC. They feature coarse cytoplasmic granules. Under a x100 objective, it is expected to observe approximately 7-15 platelets. In clinical terms, one platelet per high-power field (HPF) roughly corresponds to a circulation of approximately 15,000-20,000 platelets.[11]

Elevated platelet levels are referred to as thrombocytosis, while reduced levels are termed thrombocytopenia. Qualitative platelet abnormalities fall under the category of thrombasthenia and necessitate platelet functional studies for proper identification and assessment.[11]

Triggers for further evaluation include:[17]

- **PLT <100 x 103/µL or PLT >800 X 103/µL**

Abnormal platelet counts can prompt the need for a peripheral blood smear (PBS) review. Low platelet numbers can manifest in conditions such as immune thrombocytopenic purpura, characterized by increased platelet turnover, or in Bernard Soulier Syndrome, a disorder affecting platelet adhesion, both of which result in the presence of large or giant platelets.[11, 22]

Falsely low platelet counts may be attributed to platelet clumping, which can trigger an automated count underestimation.[21] Platelet clumping can be caused by inadequate anticoagulant or by platelet activation when drawing a blood sample.[23]

High platelet counts, known as thrombocytosis, can arise from bone marrow disorders like essential thrombocythemia or as a response to various triggers such as hypoxia, infection, or injury.[11] Falsely elevated automated platelet counts can result from the fragmentation of red or white blood cells.[23]

References

1. Kratz A, Lee SH, Zini G, Riedl JA, Hur M, Machin S; International Council for Standardization in Haematology. Digital morphology analyzers in hematology: ICSH review and recommendations. Int J Lab Hematol. 2019;41(4):437-447. doi: 10.1111/ijlh.13042

2. Lewis JE, Pozdnyakova O. Digital assessment of peripheral blood and bone marrow aspirate smears. Int J Lab Hematol. 2023;45 Suppl 2:50-58. doi: 10.1111/ijlh.14082

3. Gulati G, Song J, Florea AD, Gong J. Purpose and criteria for blood smear scan, blood smear examination, and blood smear review. Ann Lab Med. 2013;33(1):1-7. doi: 10.3343/alm.2013.33.1.1

4. Cohan P. Complete Blood Count Testers Say Their Products Can Monitor COVID-19 Patients Safely. Forbes. 18 March 2020. Available from https://www.forbes.com/sites/petercohan/2020/03/18/complete-blood-count-testers-say-their-products-can-monitor-covid-19-patients-safely/?sh=5f1cc2824a06 [Accessed 4 September 2023]

5. Bain BJ. The Peripheral Blood Smear. In: Goldman L, Schafer IE, editors. Goldman's Cecil Medicine (Twenty fourth edition). Elsevier, 2012; p 1024 – 1031

6. Katz BZ, Benisty D, Sayegh Y, Lamm I, Avivi I. Remote Digital Microscopy Improves Hematology Laboratory Workflow by Reducing Peripheral Blood Smear Analysis Turnaround Time. Appl Clin Inform. 2022;13(5):1108-1115. doi: 10.1055/a-1957-6219

7. Iscoe MS, Loza AJ, Turbiville D, Campbell SM, Peaper DR, Balbuena-Merle RI, et al. PROSER: A Web-Based Peripheral Blood Smear Interpretation Support Tool Utilizing Electronic Health Record Data. Am J Clin Pathol. 2023;160(1):98-105. doi: 10.1093/ajcp/aqad024

8. Katz BZ, Feldman MD, Tessema M, Benisty D, Toles GS, Andre A, et al. Evaluation of Scopio Labs X100 Full Field PBS: The first high-resolution full field viewing of peripheral blood specimens combined with artificial intelligence-based morphological analysis. Int J Lab Hematol. 2021;43(6):1408-1416. doi: 10.1111/ijlh.13681

9. Al Hadidi S. Blood Smear: The Fifth Vital Sign in Hematology. American Society of Hematology. 17 August 2021. Available from https://www.hematology.org/education/trainees/fellows/trainee-news/2021/blood-smear [Accessed 11 September 2023]

10. Lollie TK, Parks R, Bakic L, Ziman A, Pullarkat S. Educational cost-effective intervention to reduce pathologist's peripheral blood smears reviews with non-contributory findings: an academic institution experience. J Clin Pathol. 2022;75(3):154-158. doi: 10.1136/jclinpath-2021-207905

11. Adewoyin AS, Nwogoh B. Peripheral blood film - a review. Ann Ib Postgrad Med. 2014 Dec;12(2):71-9. PMID: 25960697; PMCID: PMC4415389

12. eClinPath. Smear Examination. Cornell University College of Veterinary Medicine. Available from https://eclinpath.com/hematology/hemogram-basics/blood-smear-examination/ [Accessed 27 August 2023]

13. Meitus A, Bentahar A. Unleashing the Power of Digital Morphology. The Pathologist.11 July 2023. Available from https://thepathologist.com/diagnostics/unleashing-the-power-of-digital-microscopy [Accessed 04 October 2023]

14. Dawande PP, Wankhade RS, Akhtar FI, Noman O. Turnaround Time: An Efficacy Measure for Medical Laboratories. Cureus. 2022;14(9): e28824. doi: 10.7759/cureus.28824

15. Robinson AT. Severe Shortages of Qualified Medical Laboratory Professionals. BioMedical Journal of Technical and Scientific Research 2023;39710-39712. DOI: 10.26717/BJSTR.2023.48.007651 https://biomedres.us/pdfs/BJSTR.MS.ID.007651.pdf

16. Garcia E, Kundu I, Kelly M, Soles R. The American Society for Clinical Pathology's 2018 Vacancy Survey of Medical Laboratories in the United States. Am J Clin Pathol 2019; 152:155-168. https://pubmed.ncbi.nlm.nih.gov/31135889/ DOI: 10.1093/ajcp/aqz046

17. Barnes PW, McFadden SL, Machin SJ, Simson E, International Consensus Group for Hematology. The International Consensus Group for Hematology Review: Suggested Criteria for Action Following Automated CBC and WBC Differential Analysis. Lab Hematol.2005;11(2):83-90. doi:10.1532/LH96.05019

18. Hamad H, Mangla A. Lymphocytosis. 2023 Jul 17. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 31747226

19. Abdou M. Approach to Lymphocytosis. Ask Hematologist | Understand Hematology. 31 October 31, 2019. Available from https://askhematologist.com/approach-to-lymphocytosis/ [Accessed 27 August 2023]

20. Bain BJ. Blood Cell Morphology in Health and Disease. In: Bain BJ, Bates I, Laffan MA. Dacie and Lewis Practical Haematology (Twelfth Edition). Elsevier, 2017: p 61-92

21. Bain BJ. Diagnosis from the Blood Smear.N Engl J Med 2005;353:498-507. DOI: 10.1056/NEJMra043442

22. Johns Hopkins Medicine. Idiopathic Thrombocytopenic Purpura. 2023. https://www.hopkinsmedicine.org/health/conditions-and-diseases/idiopathic-thrombocytopenic-purpura [Accessed 27 August 2023]

23. Nguyen A, Wahed A. Sources of Errors in Hematology Testing. In: Accurate Results in the Clinical Laboratory. Elsevier; 2019: 387-393. doi:10.1016/B978-0-12-813776-5.00025-X

Disclaimers

*Scopio's Full-Field remote capabilities are available through the secure hospital network.

**Scopio's X100/ X100HT with Full-Field Peripheral Blood Smear™ Application is CE marked and FDA cleared. The availability of the RBC-DSS capability may vary by region. While this technology is not yet available for commercial use in the United States and CE-countries, we are actively working to make it accessible as well as in additional regions.

Digital hematology in focus:

The clinical impact of Full-Field technology

Scopio

scopiolabs.com