

Pancytopenia demystified: A proposed diagnostic algorithm for the strategic evaluation of pancytopenia

Madeeha Rehan, Rafia Behzad, Sahrish Bari, Attika Khalid

Fauji Foundation Hospital, Rawalpindi Pakistan

ABSTRACT

Objective: To design a simplified minimally invasive algorithm for strategic diagnostic approach towards pancytopenia by evaluating the etiological spectrum of pancytopenia in a tertiary care hospital.

Material and Methods: It was a retrospective study which was conducted at Fauji Foundation Hospital Rawalpindi. The duration of study was 3 years, i.e. January 2022 - January 2025. Patients of both genders and all ages who were diagnosed as having pancytopenia were included in the study. All pancytopenia were verified on peripheral smear. Results of other diagnostic workup done to identify the etiology of pancytopenia including reticulocyte count, malarial parasite (MP), serum iron profile, vitamin B12 levels, red blood cell (RBC) folate, blood cultures etc. and of different imaging techniques were noted.

Results: Out of total 216 patients 174 were females and 42 were male. Non-malignant cases in patients presented with pancytopenia were 181. Whereas 35 cases (16.2%) showed various malignant disorders. Among the non-malignant disorders, the most common etiology was infections (27%) followed by megaloblastic anemia (19%). In malignant disorders acute lymphoblastic and acute myeloid leukemia comprised the largest bulk (40%). Non-diagnostic marrows were 37%. After a thorough evaluation of generated data, a simplified algorithm is designed to opt for a strategic approach towards diagnosis of pancytopenia.

Conclusion: Among various causes of pancytopenia, megaloblastic infections and aplastic anemia were the most common causes. Thorough and logical evaluation and strategic diagnostic approach following algorithm will help to reduce mortality and morbidity in patients presenting with pancytopenia.

Keywords: Bone marrow examination, Malignant disorders, Pancytopenia.

This article can be cited as: Rehan M, Behzad R, Bari S, Khalid A. Pancytopenia demystified: A proposed diagnostic algorithm for the strategic evaluation of pancytopenia. Pak J Pathol. 2025; 36(3): 196-204. DOI: <https://doi.org/10.55629/pakjpathol.v36i3.929>

INTRODUCTION

Pancytopenia is not a diagnosis itself but is characterized by a decrease in all three cell lineages (Hemoglobin (Hb), Total leucocyte count (TLC) and Platelets (Plt). It is defined as hemoglobin level <than 12 g/dL in females and <13gm/dl in males, total leucocyte count (TLC) < 4×10^9 /L / absolute neutrophil count (ANC) < 1.5×10^9 /L, and platelet count < 100×10^9 /L

[1]. Common clinical features usually include fatigue, infections and bleeding. Although the etiology of pancytopenia is extensive, but nutritional deficiencies are the commonest. Vitamin B12 deficiency results in defective DNA synthesis and megaloblastic anemia eventually leading to pancytopenia [2]. Similarly, folate deficiency and certain medications such as methotrexate can result in megaloblastic anemia and pancytopenia. Copper deficiency or zinc excess are fewer common causes leading to pancytopenia [3]. Aplastic Anemia results in pancytopenia due to hypocellular bone marrow and reduced production of all three cell lineages. Other differentials, especially in younger patients include, inherited bone marrow failure syndrome, such as Schwachman–Diamond

Correspondence: Dr. Madeeha Rehan, Department of Pathology, Fauji Foundation Hospital, Rawalpindi Pakistan

Email: r.madeeha138@gmail.com

Receiving Date: 08 Jul 2025

Revision Date: 07 Aug 2025

Acceptance Date: 16 Sep 2025



Copyright © 2025. Madeeha Rehan, *et al.* This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License, which permits unrestricted use, distribution & reproduction in any medium provided that original work is cited properly.

syndrome, Fanconi anemia, and dyskeratosis congenita [4]. However, splenomegaly and lymphadenopathy are unusual in Aplastic Anemia, and in their presence, infections should be considered instead. Aplastic anemia is diagnosed by bone marrow aspiration and trephine biopsy [5].

Hemophagocytic lympho-histiocytosis (HLH) is a rare but fatal disease of overactive histiocytes and lymphocytes. In view of the fatality of disease early detection and immediate treatment is required [6]. Radiation therapy can lead to Bone marrow Hypoplasia [7]. Severe acute respiratory syndrome by coronavirus 2 (SARS-CoV-2) also reported resulting in pancytopenia [8, 9]. Various infections such as parvovirus B19 and human immunodeficiency virus (HIV), Leishmaniasis and Hepatitis C infection can also impair bone marrow production, thus leading to pancytopenia [10, 11].

Bone marrow infiltration by inherited storage disorder such as Gaucher disease may result in pancytopenia [12]. Various malignancies including lymphoma, leukemia, multiple myeloma, metastatic tumors and different granulomatous diseases can lead to pancytopenia by causing bone marrow infiltration [13,14]. Drug toxicities by chemotherapeutic agents and other drugs including chloramphenicol, dapsone, carbamazepine and carbimazole can lead to pancytopenia [15].

Pancytopenia is a significant diagnostic challenge due to its broad spectrum of underlying causes. While numerous etiologies have been overused, there remains a notable scarcity of literature particularly at the local, regional, and national levels [16]. In the absence of standardized protocols, clinicians often resort to individualized diagnostic approaches, frequently involving invasive procedures such as bone marrow examinations, even when they may not be immediately warranted.

This study aims to develop a minimally invasive diagnostic algorithm tailored according to the demographic and etiological patterns observed in patients presented with pancytopenia in our population. By establishing a context-specific

approach, this research intends to assist pathologists and clinicians in reaching accurate diagnosis more efficiently, thereby reducing unnecessary laboratory workload, minimizing the financial burden on patients, and curbing the overuse of invasive investigations. Ultimately, this study seeks to enhance diagnostic precision and streamline patient care in cases of pancytopenia within our healthcare setting.

MATERIAL AND METHODS

This was a retrospective observational study which was conducted in the department of Hematology, Fauji Foundation Hospital Rawalpindi. Ethical approval was taken from the institutional ethical review board (Ref No 983/RC/FFH/RWP dated 11th August 2020). The study was carried out from January 2022 to January 2025. Patients of all ages and both genders were included in the study. Data was exported from Sysmex analyzer and was processed in excel. Hospital software was used to retrieve radiological and laboratory data including CBC, peripheral smear findings with all other ancillary investigations. All blood samples received in the Hematology section of the FFH for Complete blood counts (CBC) from the in-patient and outpatient department during this time span were processed on Fully automated Hematology Analyzer Sysmex XN-1000 series. All CBC showing pancytopenia (hemoglobin <13 g/dL in males and 12gm/dl in females, a platelet counts of $<100 \times 10^9/L$ and an absolute neutrophil count of $<1.5 \times 10^9/L$) were verified on peripheral smears. Patients with a known diagnosis of pancytopenia or on chemotherapy or radiotherapy were excluded from the study. Reticulocyte count was also performed on Sysmex XN-1000 series. Morphological details of all peripheral smears stained with Leishman stain were noted. Details regarding presence or absence of blasts, malarial parasites, any red cell or white cell inclusions and platelet clumping were reported. Results from a comprehensive range of investigations were recorded, including serum iron profile, lactate dehydrogenase (LDH), vitamin B12 levels, red blood cell (RBC) folate, blood cultures, liver function tests (LFTs),

renal function tests (RFTs) and autoimmune panels. Infections in our study were categorized based on clinical diagnosis supported by lab confirmation. Viral infections included dengue (confirmed by NS1 antigen), infectious mononucleosis (confirmed by EBV serology), COVID-19 (RT-PCR), and other viral infections as identified through relevant serological tests. Bacterial infections included typhoid fever (confirmed by positive blood culture), while fungal infections included candidiasis (confirmed by fungal culture).

In addition, data for chronic viral hepatitis serology and HIV screening, Quantiferon Gold, and GeneXpert for tuberculosis were also documented. Imaging findings from ultrasound and CT scans, as well as results from bone marrow aspiration and trephine biopsies were systematically included

Data was scrutinized on SPSS version 21.0. Statistical analysis comprised of descriptive stats (mean, standard deviation (SD), Confidence interval (CI), frequency distribution and percentages)

RESULTS

After excluding diagnosed cases, patients on chemotherapy or repeat samples of the same patient in the tenure of their admission, the undiagnosed/new pancytopenia cases were found to be 216.

Patients of all age groups were included in the study meeting the prerequisites. Gender distribution shown in (Table-I). Pancytopenia cases were divided into three groups according to the age bracket i.e. above 50 years, between 30-50 years and below 30 years. 50% (108) cases of all pancytopenia cases were noted in patients of either gender above 50 years of age

whereas in the 50% below 50 years, the second peak was noted in patients below 30 years i.e. 60 cases (Table-II). The incidence of non-malignant cases in patients with pancytopenia was 181 (83%) whereas 35 cases (16.2%) showed malignant disorders. The most common non-malignant etiology has been found to be infection (27%) followed by megaloblastic anemia (19%) with acute leukemia group including acute lymphoblastic and acute myeloid leukemia comprising the largest bulk (40%) in malignant cases presented with pancytopenia. (Figure I and II) The mean and standard deviation of WBC, Hemoglobin and platelet of non-malignant group is shown in table-III. As per results in malignant disorders Mean Hemoglobin found out to be 6.79 gm/dl, Mean TLC was $2.08 \times 10^3/\mu\text{L}$ and Mean Platelet count calculated was $41.46 \times 10^3/\mu\text{L}$. Out of total patients, Bone Marrow Biopsy was performed on 70 patients. Percentage of patients with diagnostics bone marrow findings was 63%, while the number of patients in which bone marrow biopsy was not required was found to be 37%. Table 4 shows Outcomes of Bone Marrow Examination in Pancytopenia with Diagnostic Yield, while Table 5 depicts those patients with pancytopenia who possibly underwent unjustified procedures.

Keeping in view the above-mentioned results a simplified algorithm has been designed for devising a strategic and logical approach towards pancytopenia (Figure-III) However Sequence of investigations can be tailored according to the clinic-pathological consensus of physicians.

Chronic disease includes chronic liver disease, chronic hep B and C viral infections, chronic kidney disease, diabetes mellitus and neurological disorder.

Table-I: Gender distribution in pancytopenia patients.

Total number of cases	Pancytopenia in female	Pancytopenia in males
216	174	42
100%	80.5	19.5

Table-IIA: Age specific mean values, standard deviations and confidence interval of WBCs and HGB among Malignant and non-malignant cases.

Stratum	Non malignant	Malignant	Non-Malignant cases WBC Mean +_SD (10 ³ /uL) A		Malignant cases WBC Mean + SD (10 ³ /uL) B		WBC 95 % CI (10 ³ /uL) A & B		Non-Malignant cases HGB Mean +_SD (g/dL) A		Malignant cases HGB Mean +_SD (g/dL) B		HGB 95 % CI (g/dL) A & B	
<30	60	6	2.46	0.97	1.95	0.98	(2.22, 2.71)		7.43	2.03	7.93	1.70	(7.00, 7.86)	
30-50	35	6	2.26	1.23	2.39	0.78	(1.93, 2.60)		7.31	1.54	5.85	1.12	(6.67, 7.95)	
>50	86	23	2.55	0.94	2.03	1.11	(2.35, 2.76)		7.37	1.84	6.73	1.70	(7.03, 7.72)	

Table-II B: Age specific Mean values, Standard Deviations and Confidence interval of PLT among Malignant and Non-Malignant Cases

Stratum	Non malignant	Malignant	Non-Malignant cases PLT Mean + SD (10 ³ /uL) A		Malignant cases PLT Mean + SD (10 ³ /uL) B		PLT 95 % CI (10 ³ /uL) A & B	
<30	60	6	44.7	23.84	40.83	27.62	(38.84, 50.56)	
30-50	35	6	43.54	28.02	45.16	32.18	(34.41, 52.67)	
>50	86	23	46.18	26.74	40.65	31.96	(40.26, 52.11)	

Table-III: Mean, standard deviation and *confidence interval of WBC, HGB and PLT in common non- malignant pancytopenia patients.

Category	No of Patients	WBC Mean ± SD with 95% CI (10 ³ /uL)			HGB Mean ± SD with 95% CI (g/dL)			PLT Mean ± SD with 95% CI (10 ³ /uL)		
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI
Non-malignant (all)	181	2.469	1.013	(2.32, 2.62)	7.382	1.849	(7.11, 7.65)	45.182	25.952	(41.38, 48.99)
Mixed deficiency anemia	17	2.586	1.081	(2.03, 3.14)	8.612	1.350	(7.92, 9.31)	47.941	25.420	(34.87, 61.01)
Chronic Disease	26	2.043	0.931	(1.67, 2.42)	7.469	1.867	(6.72, 8.22)	37.231	24.417	(27.37, 47.09)
Megaloblastic anemia	34	2.581	0.913	(2.26, 2.90)	7.076	2.029	(6.37, 7.78)	53.088	25.547	(44.17, 62.00)
Infection	24	2.646	1.190	(2.14, 3.15)	7.379	1.631	(6.69, 8.07)	45.750	26.049	(34.75, 56.75)

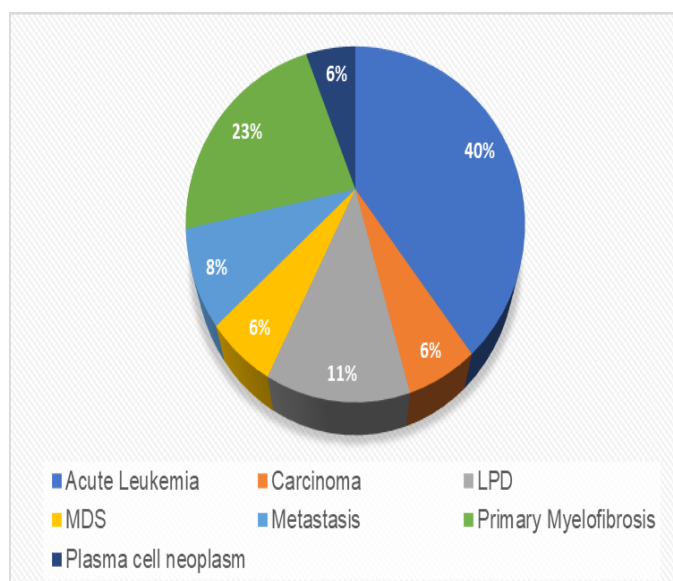
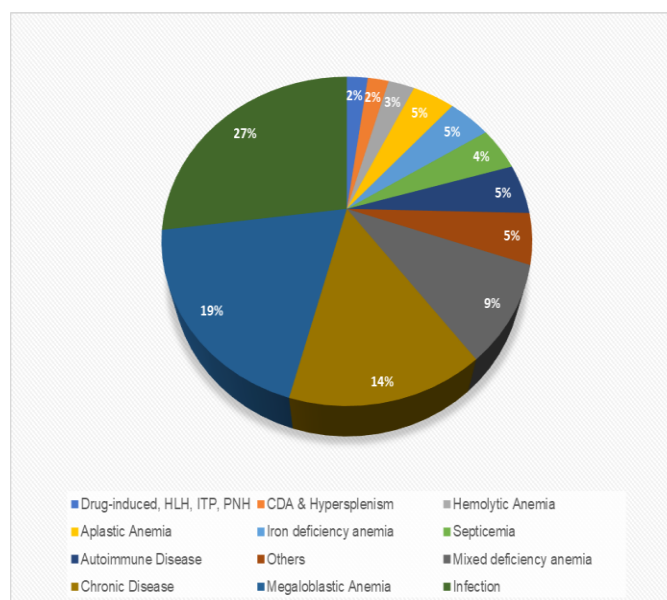
*Although this study is descriptive and not intended to compare groups statistically, 95% confidence intervals were included to provide an estimate of precision around mean laboratory values.

Table-IV: Outcomes of bone marrow examination in pancytopenia: Diagnostic yield.

Disease	No of Patients
Acute Leukemia	11
Primary myelofibrosis	5
Hypocellular Marrow	5
Lymphoproliferative disorder	4
Aplastic anemia	4
Myelodysplastic syndrome	3
Chronic myeloid leukemia	2
Metastasis	2
Cancer	2
Plasma cell leukemia	1
Multiple Myeloma	1
Paroxysmal Nocturnal Hemoglobinuria	1
Hemophagocytic Lymphohistiocytosis	1
Congenital Dyserythropoietic Anemia	1
Tuberculosis	1

Table-V: Outcomes of Bone Marrow Examination in Pancytopenia: *Possibly unjustified procedures.

Disease	No of Patients
Megaloblastic anemia	9
Mixed deficiency anemia	5
Iron deficiency anemia	1
Reactive changes	4
Hypersplenism	2
Autoimmune Disease	2
Chronic liver disease	2
Drug Induced	1

**Figure-I: Incidence of malignant cases among Pancytopenic patients.****Figure-II: Incidence of non-malignant cases among pancytopenia patients.**

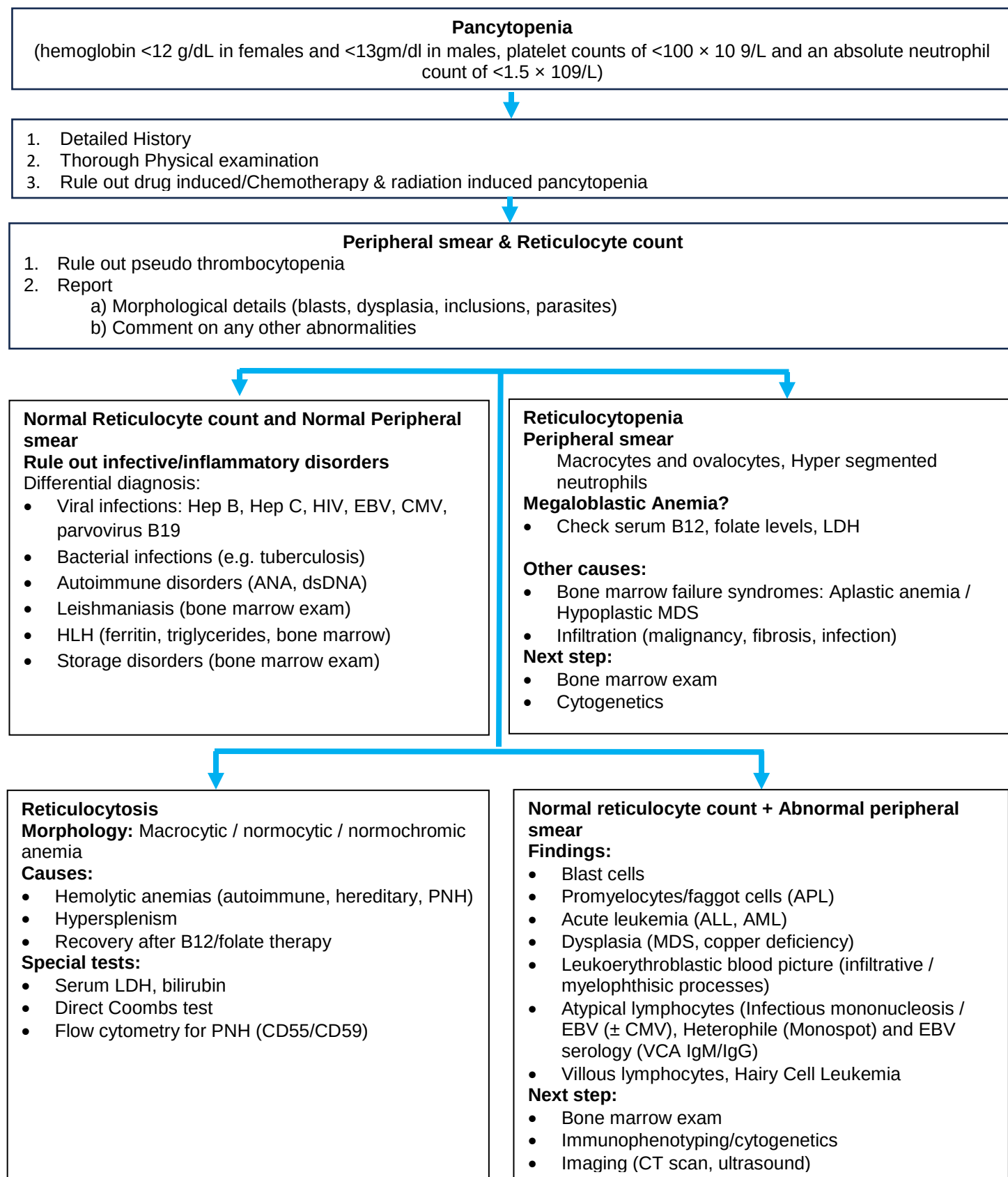


Figure-III: Diagnostic algorithm for pancytopenia.

Algorithm for pancytopenia: NRBC.S: Nucleated red blood cells. LFT, S: Liver function tests, RFT, S: Renal function tests, ESR: Erythrocyte Sedimentation rate, CRP: C-reactive proteins: cytomegalovirus, CT: computed tomography, DAT: direct antiglobulin test, EBV: Epstein–Barr virus, Hb: hemoglobin, HIV: human immunodeficiency virus. PNH: Paroxysmal nocturnal Hemoglobinuria, MDS: Myelodysplastic syndrome

DISCUSSION

Pancytopenia is not a clinical disorder itself but a manifestation of various underlying illnesses. Decreased production of hematopoietic cells, such as aplastic anemia, bone marrow infiltration from hematological and non-hematological malignancies, various autoimmune disorders, hypersplenism, ineffective erythropoiesis such as megaloblastic anemia and hemolytic anemia, and different infections are a few of the many possible mechanisms behind the development of pancytopenia [17,18]. In a study conducted by Sreenivas *et al.*, a total of 100 patients were included. According to the results of this study, megaloblastic anemia (64%) and aplastic anemia were found to be the commonest causes of pancytopenia. Other causes observed were chronic liver disease, hematological malignancies, infections like HIV and malaria. This contrasts with our study, in which infections were found to be the most common cause and aplastic anemia was found to be the second most common cause. According to the results of this study, only 10% of cases were diagnosed with aplastic anemia, whereas in our study, 14% of cases were diagnosed with aplastic anemia. Only one patient with pancytopenia associated with leukemia was identified in this study. However, in our study, a significant number of cases of malignancies were found to be associated with pancytopenia [19]. In a study conducted by Inayat *et al.*, out of the total participants, 74 males (61.7%) and 46 females (38.3%) presented with pancytopenia. In contrast to our study, megaloblastic anemia was the most common cause, accounting for 48 (40%) of the cases. The second most common cause identified was infection-related changes in 20 (16.7%) patients, and the third most common cause was aplastic anemia [20]. In our study, 40% of cases were attributed to megaloblastic anemia. The results of our study were consistent with findings from other studies, including one by Zulfiqar *et al.*, in which 29.6% of cases were reported as megaloblastic anemia [21]. Another study conducted in Pakistan by Farooque *et al.*

also revealed that the leading cause of pancytopenia was megaloblastic anemia [17].

A study conducted by Ullah *et al.* on a pediatric population with a sample size of 131 revealed that the most prevalent etiology was aplastic anemia, found in 47 (35.9%) of the cases, while the second most common cause of pancytopenia was megaloblastic anemia, diagnosed in 24 (18.3%) patients. In contrast to our study, their target population was pediatric, whereas in our study, most participants were adults [22]

According to the study by Vargas-Carretero *et al.*, the common causes identified leading to pancytopenia were megaloblastic anemia, aplastic anemia, and hypersplenism. Malignancies included myelodysplastic syndrome and acute myeloid leukemia. Various viral and bacterial infections, autoimmune disorders, and certain medications were also identified as common causes of pancytopenia. Different life-threatening clinical conditions, such as disseminated intravascular coagulopathy (DIC), hemophagocytic lymphohistiocytosis (HLH), and paroxysmal nocturnal hemoglobinuria (PNH), were also identified in patients presenting with pancytopenia. This further supports the notion that the geodemographic distribution of etiologies varies, underscoring the need for a population-specific approach to diagnosis and highlighting differences from international studies ⁽²³⁾. In our study, the mean hemoglobin (Hb) level in non-malignant patients was 7.3 g/dL, the total leukocyte count (TLC) was $2.4 \times 10^3/\mu\text{L}$, and the mean platelet count was $45.1 \times 10^3/\mu\text{L}$. In contrast, for malignant cases, the mean Hb was 7.9 g/dL, the mean TLC was $1.9 \times 10^3/\mu\text{L}$, and the mean platelet count was $40.8 \times 10^3/\mu\text{L}$.

Diagnostic Algorithm designed in this study is based on etiological spectrum extracted from the data over the span of three years in a tertiary care hospital. Moreover, no such algorithm has been designed to date at national level.

Data evaluation in our study revealed 37% unnecessary/ avoidable bone marrow aspiration and trephine biopsies which could have been avoided if strategic approach was opted for

diagnosis. This finding advocates the potential of the algorithm to optimize diagnostic workup. Minimally invasive diagnostic approach can be helpful in avoiding unnecessary hospital stay, financial burden on patients, trauma of invasive procedure and delay in treatment. We recommend clinicians consider adapting this algorithm into their diagnostic workup particularly in resource-constraint environments. This algorithm has been shared with clinicians and their feedback response will be monitored as how it has helped them in making diagnosis of patients with pancytopenia with minimally invasive investigations.

LIMITATION OF THE STUDY

1. It was a single center study
2. Internal validation was only done by identifying unnecessary bone marrows in patients and it remained limited being a retrospective study.
3. The designed algorithm has not been tested prospectively, and its diagnostic accuracy including sensitivity and specificity needs to be established through proper evaluation. Also, clinical decision making as well as individual patient variables must always support algorithm-based decisions.

RECOMMENDATION

Further multicenter studies on national level should be conducted for a validation of the diagnostic algorithm devised in this study.

CONCLUSION

Pancytopenia is a common diagnostic challenge encountered by clinicians. Establishing the underlying etiology is crucial, as various causes can lead to pancytopenia and must be identified before a final diagnosis can be made. Non-malignant causes are more frequently associated with pancytopenia than malignant ones. It is recommended that minimally invasive diagnostic algorithm can be followed for diagnosis of underlying cause of pancytopenia. These initial tests should aim to identify common causes before proceeding to more invasive

diagnostic procedures, such as bone marrow examination or imaging techniques.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

AUTHORS CONTRIBUTION

Madeeha Rehan: Substantial contributions to study design, acquisition of data, manuscript drafting or reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication.

Rafia Behzad: Manuscript drafting or reviewing it critical for important intellectual content, has given, final approval of the version to be published.

Sahrish Bari: Substantial contributions to acquisition of data, manuscript drafting or reviewing it critical for important intellectual content, final approval of the version to be published.

Attika Khalid: Critical review, proofreading, final approval of the version to be published.

REFERENCES

1. Gajbhiye SS, Karwa AR, Dhok A, Jadhav SS. Clinical and etiological profiles of patients with pancytopenia in a tertiary care hospital. *Cureus*. 2022; 14(10): e30449. DOI: <https://doi.org/10.7759/cureus.30449>
2. Thain A, Hart K, Ahmadi KR. Addressing the gaps in the vitamin B12 deficiency 2024 NICE guidelines: highlighting the need for better recognition, diagnosis, and management of pernicious anemia. *Eur J Clin Nutr*. 2025; 79 (7): 607-10. DOI: <https://doi.org/10.1038/s41430-025-01583-4>
3. Tahir N, Ashraf A, Waqar SHB, Rafae A, Kantamneni L, Sheikh T, *et al*. Copper deficiency, a rare but correctable cause of pancytopenia: A review of literature. *Expert Rev Hematol*. 2022; 15(11): 999–1008. DOI: <https://doi.org/10.1080/17474086.2022.2142113>
4. Park M. Overview of inherited bone marrow failure syndromes. *Blood Res*. 2022;57(S1):49–54. DOI: <https://doi.org/10.5045/br.2022.2022012>
5. Kulasekararaj A, Cavenagh J, Dokal I, Foukanelli T, Gandhi S, Garg M, *et al*. Guidelines for the diagnosis and management of adult aplastic anemia: A British Society for Haematology guideline. *Br J Haematol*. 2024; 204(3): 784–804. DOI: <https://doi.org/10.1111/bjh.19236>

6. Hines MR, von Bahr Greenwood T, Beutel G, Beutel K, Hays JA, Horne A, *et al.* Consensus-based guidelines for the recognition, diagnosis, and management of hemophagocytic lymphohistiocytosis in critically ill children and adults. *Crit Care Med.* 2022; 50(5): 860–72. DOI: <https://doi.org/10.1097/ccm.00000000000005361>
7. Zhang Y, Chen X, Wang X, Chen J, Du C, Wang J, *et al.* Insights into ionizing radiation-induced bone marrow hematopoietic stem cell injury. *Stem Cell Res Ther.* 2024;15:222. DOI: <https://doi.org/10.1186/s13287-024-03853-7>
8. Tang N, Li D, Wang X, Sun Z. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. *J Thromb Haemost.* 2020;18(4): 844–7. DOI: <https://doi.org/10.1111/jth.14768>
9. Al-Samkari H, Karp Leaf RS, Dzik WH, Carlson JCT, Fogerty AE, Waheed A. COVID-19 and coagulation: bleeding and thrombotic manifestations of SARS-CoV-2 infection. *Blood.* 2020; 136(4): 489–500. DOI: <https://doi.org/10.1182/blood.2020006520>
10. Hussain S, Hussain I, Ashfaq A, Karim LA, Mirza S, Zafar H. Bone marrow aplasia in Hemophilia-A with Hepatitis-C and human immunodeficiency virus co-infection: A case report. *J Pak Med Assoc.* 2022; 72(11): 2323–6. DOI: <https://doi.org/10.47391/jpma.4659>
11. Takele Y, Mulwa T, Adem E, Shaw CJ, Franssen SU, Womersley R, *et al.* Immunological factors, but not clinical features, predict visceral leishmaniasis relapse in patients co-infected with HIV. *Cell Rep Med.* 2022; 3(1): 100487. DOI: <https://doi.org/10.1016/j.xcrm.2021.100487>
12. Adawiye A, Baydoun O, Samaha H, El Georges, Hachem. Gaucher disease on the ruins of multiple myeloma: an unusual presentation. *Clin Lymphoma Myeloma Leuk.* 2023; 23(1): S 482. DOI: [https://doi.org/10.1016/S2152-2650\(23\)01419-2](https://doi.org/10.1016/S2152-2650(23)01419-2)
13. Çordan I, Tukek T. Evaluation of etiological causes and incidence of pancytopenia: a case series from a tertiary care center. *Cureus.* 2025; 17(2): e79485. DOI: <https://doi.org/10.7759/cureus.79485>
14. Takeshima M, Ishikawa H, Kitadate A, Sasaki R, Kobayashi T, Nanjyo H, *et al.* Anorexia nervosa-associated pancytopenia mimicking idiopathic aplastic anemia: A case report. *BMC Psychiatry.* 2018; 18(1): 150. DOI: <https://doi.org/10.1186/s12888-018-1743-6>
15. Xiao N, Hao S, Zhang Y, Shao Z. Roles of immune responses in the pathogenesis of immunorelated pancytopenia. *Scand J Immunol.* 2020; 92(2): e12911. DOI: <https://doi.org/10.1111/sji.12911>
16. Fazal W, Khan S, Akhtar R, Khattak SA, Ali M, Kakakhel M. A comprehensive analysis of clinical presentations, laboratory findings, and etiologies of pancytopenia: a tertiary care experience. *Cureus.* 2024; 16(11): e73148. DOI: <https://doi.org/10.7759/cureus.73148>
17. Farooque R, Iftikhar S, Herekar F, Patel MJ. Frequency and etiology of pancytopenia in patients admitted to a tertiary care hospital in Karachi. *Cureus.* 2020;12:e. DOI: <https://doi.org/10.7759/cureus.11057>
18. Patel GR, Prajapati GR. Spectrum of pancytopenia in adults attending a clinical hematology department: A four-year experience from a tertiary care center of western India. *Cureus.* 2022; 14: e24933. DOI: <https://doi.org/10.7759/cureus.24933>
19. Sreenivas S, Harika ML, Hyma T, Mounika G. Etiology of pancytopenia in a study in a tertiary care hospital in North Andhras. *J Med Sci Clin Res.* 2020; 8(8): 2455–450. DOI: <https://doi.org/10.18535/JMSCR/V8I8.45>
20. Ullah I, Khan D, Qureshi V. Etiological spectrum of bone marrow biopsy in patients with pancytopenia. *Cureus.* 2024; 16(11): e73138. DOI: <https://doi.org/10.7759/cureus.73138>
21. Zulfikar M, Ali BA, Jiskani SA, Waqar M, Saad M, Javed H. Evaluation of pancytopenia based on bone marrow examination in adults in a tertiary care hospital in Islamabad. *Prof Med J.* 2023; 30(8): 1152–6. DOI: <https://doi.org/10.29309/TPMJ/2023.30.09.7575>
22. Ullah I, Khan MS, Fayaz M, Khan SA, Khan N, Tabassum R. Understanding the etiologies of pancytopenia in pediatric patients: A cross-sectional study. *Int J Biomed Res.* 2025; 3(1): 185-9. DOI: <https://doi.org/10.70749/ijbr.v3i1.384>
23. Vargas-Carretero CJ, Fernandez-Vargas OE, Ron-Magaña AL, Padilla-Ortega JA, Ron-Guerrero CS, Barrera-Chairez E. Etiology and clinico-hematological profile of pancytopenia: experience of a Mexican tertiary care center and review of the literature. *Hematol.* 2019; 24(1): 399–404. DOI: <https://doi.org/10.1080/16078454.2019.1590961>