

Spectrum of Myeloproliferative Neoplasm and Myelodysplastic / Myeloproliferative Neoplasm in a Tertiary Hospital, JNIMS

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ABSTRACT

BACKGROUND

Myeloproliferative neoplasms (MPN) are a group of haematopoietic stem cell disorders leading to clonal myeloproliferation characterized by granulocytosis, erythrocytosis and / or thrombocytosis. Myelodysplastic / myeloproliferative neoplasms (MDS / MPN) are neoplasms of the haematopoietic stem cells which show features of both myeloproliferative and myelodysplastic neoplasms. Incidence of MPN and MDS / MPN are sparse due to lack of proper data or registry. We wanted to evaluate the spectrum of MPN and MDS / MPN cases diagnosed in a tertiary care hospital within a two and a half year period.

METHODS

This is a retrospective cross-sectional study. All the information was obtained from the bone marrow and clinical OPD registers maintained in the concerned departments. Correlation of complete haemogram & bone marrow findings with molecular and genetics analysis was also done in some of the cases. The 2017 revised edition of WHO classification of tumours of haematopoietic and lymphoid tissues was adopted for categorization.

RESULTS

A total of 42 cases was studied including 40 cases of MPN and 2 cases of MDS / MPN. Out of the 40 cases of MPN, 20 cases of chronic myeloid leukaemia (CML), 14 cases of polycythaemia vera (PV), 3 cases of primary myelofibrosis (PMF), and 3 cases of essential thrombocythaemia (ET) were observed. Amongst the CML cases, 30 % were in blast crisis at presentation. All the cases with lymphoid blast crisis were of B-cell phenotype. Molecular study for BCR-ABL1 was done for all the cases. JAK2V617F and CALR mutation was noted in 67 % of PMF and ET cases respectively. Monosomy 7 was detected in 1 case of Juvenile myelomonocytic leukaemia (JMML).

CONCLUSIONS

In our study, we found certain clinico haematological profiles different from those of other studies which may be contributed to geographical and racial distribution. However, a thorough health investigation is needed.

KEYWORDS

Myeloproliferative Neoplasms (MPN), Granulocytosis, Erythrocytosis, Thrombocytosis, Myelodysplastic, Polycythaemia Vera (PV), Essential Thrombocythaemia (ET)

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BACKGROUND

Myeloproliferative neoplasms (MPNs) are a group of clonal disarrays, resulting from aberrant stem cell myeloproliferation.¹ characterized by granulocytosis, erythrocytosis with or without thrombocytosis.² On the other hand, myelodysplastic / myeloproliferative neoplasms are neoplasms of the haematopoietic stem cells which show the clinical, morphological and laboratory features of both myelodysplastic and myeloproliferative neoplasm.¹ According to 2017 revised edition of WHO classification of tumours of haematopoietic and lymphoid tissues, MPNs included chronic myeloid leukaemia (CML), chronic neutrophilic leukaemia (CNL), polycythaemia vera (PV), primary myelofibrosis (PMF), essential thrombocythaemia (ET), chronic eosinophilic leukaemia, not otherwise specified and myeloproliferative neoplasm, unclassifiable.³ Although microscopic pictures of blood and bone marrow along with clinical features are necessary for diagnosis of MPN and MDS / MPN, genetic information also play a critical role and fulfilment of certain criteria are mandatory for proper classification. Detection of BCR-ABL1 is the basis for diagnosing CML which distinguishes it from other MPN and MDS / MPN, where it is not found.⁴

The chronic phase of CML (CML-CP) is more commonly seen during diagnosis which has leukocytosis with neutrophilia, absolute eosinophilia and basophilia. Blasts are usually <2 %. In CML-CP the platelets count may be normal or increased. In the blast phase, the blasts should be ≥ 20 % of the WBCs in either blood or bone marrow or extramedullary blasts proliferation. Presence of other gene rearrangement such as JAK2 V617F is one of the major diagnostic criteria in most of the BCR-ABL1 negative MPN and MDS / MPN.⁵ In PV, JAK2 V617F or JAK2 exon 12 mutation is one of the major diagnostic criteria. Presence of increased haemoglobin concentration (>16.5 g / dL in male or >16g / dL in female) or increased haematocrit (>49 % in males; >48 % in females) or increased in red cell mass along with increased age-adjusted hypercellularity with trilineage hyperplasia in case of bone marrow biopsy also constitute the major criteria for the diagnosis of PV. The minor criteria include presence of subnormal erythropoietin level. Bone marrow biopsy is not required if the haematocrit is >49.5 % in females or >55.5 % in males and haemoglobin concentration >16.5 g / dL in females or >18.5g / dL in males in the presence of other major and minor criteria for the diagnosis of PV.³

In 2013, gene mutation of CALR was discovered in 50-80 % of JAK2 V617F- negative ET and PMF but it was not described in cases of PV. Other laboratory tests including serum erythropoietin, lactate dehydrogenase level as well as leukoerythroblastic blood picture are also important in diagnosis.⁶ In the case of PMF, reticulin fibrosis along with increased bone marrow cellularity abnormal megakaryocytic proliferation and JAK2, CALR or MPL mutation are seen. The minor criteria included leukocytosis, anaemia, splenomegaly, leukoerythroblastosis and increased LDH. While JAK2, CALR or MPL mutation, thrombocytosis without any reactive causes and bone marrow biopsy showing increased mature megakaryocytes having hyperlobulated nuclei (staghorn

appearance) are seen in ET.³ Cases that do not fulfil the criteria of either MPN or MDS are grouped into MDS / MPN such as chronic myelomonocytic leukaemia (CMML), atypical chronic myeloid leukaemia (aCML), juvenile myelomonocytic leukaemia (JMML), myelodysplastic / myeloproliferative neoplasm with ring sideroblasts and thrombocytosis, and myelodysplastic / myeloproliferative neoplasm, unclassifiable.^{3,4} Persistent monocytosis in the absence of any inflammation, infection or malignancy with dysplasia of one more of the myeloid series are some of the major criteria for CMML. In JMML, besides monocytosis, blasts <20 % in blood or bone marrow and splenomegaly should be present without any BCR-ABL1 mutation. Monosomy 7 or any other mutations can also be associated.³ On literature search, there are very few studies evaluating the spectrum of MPNs and MDS / MPNs.^{7,8,9} Hence this study has been undertaken to evaluate the clinico haematological profile of MPN and MDS / MPN cases diagnosed in a tertiary care hospital.

METHODS

This is a retrospective cross-sectional study. All the information was obtained from the bone marrow and clinical OPD registers maintained in the Pathology and Medicine departments, Jawaharlal Nehru Institute of Medical Sciences, Imphal. Findings of complete hemogram, bone marrow aspirate & biopsy were analysed. These findings were correlated with biochemical, molecular and genetics analysis reports to come to a diagnosis. We calculated the incidences of different categories of MPN and MDS / MPN, the percentage of patients presenting with different categories of anaemia (according to the WHO guidelines), total leucocyte count (TLC) higher or lower than $10 \times 10^9 / L$ and platelet counts higher or lower than $100 \times 10^9 / L$ were evaluated. In CMML, those presenting TLC < $13 \times 10^9 / L$ or $\geq 13 \times 10^9 / L$ are assessed separately. In bone marrow examination, certain features such as cellularity, blast percentage, megakaryocyte morphology, Myeloid: Erythroid ratio and trilineage hyperplasia were taken into account. Molecular study for BCR-ABL1, JAK2V617F, CALR mutation were done along with flowcytometric and cytogenetic analysis whenever indicated. The 2017 revised edition of WHO classification of tumours of haematopoietic and lymphoid tissues was adopted for categorization. Appropriate statistical methods including independent t-test and chi square test were utilized.

RESULTS

A total of 42 cases was studied including 40 cases of MPN and 2 cases of MDS / MPN. Out of these, 20 cases (48 %) of chronic myeloid leukaemia (CML), 14 cases (33 %) of polycythaemia vera (PV), 3 cases (7 %) of primary myelofibrosis (PMF), and 3 cases (7 %) of essential thrombocythaemia (ET) 1 case (3 %) of juvenile myelomonocytic leukaemia (JMML) and 1 case (2 %) chronic myelomonocytic leukaemia (CMML) were also observed

[Table. 1]. Male were predominant than females in CML whereas in PMF and ET females were predominant. The mean age was higher in PMF than other MPNs while it was lowest in PV. The median total leucocyte count was higher in CML ($77 \times 10^9 / L$) than PV ($6.6 \times 10^9 / L$), ET ($10.3 \times 10^9 / L$) and PMF ($4.6 \times 10^9 / L$). PV ($20 \pm 1.6 \text{ g / dL}$) had the highest mean haemoglobin whereas the highest median platelet count was seen in ET ($435 \times 10^9 / L$) [Table. 2].

Chronic Myeloid Leukaemia (CML)

In CML, 14 cases (70 %) were in chronic phase while 6 cases (30 %) were in blast crisis. No cases of accelerated phase were included. In chronic phase of CML, male predominance (64.2 %) was seen while the mean age was 42 ± 15.57 years. The mean haemoglobin was 10.3 g / dL . 11 cases (78 %) presented with anaemia. 7 cases (50 %) had mild anaemia, 2 cases (14 %) had moderate anaemia and 2 cases (14 %) had severe anaemia. 93 % had total leucocyte count $> 10 \times 10^9 / L$, while 7 % had $< 10 \times 10^9 / L$. The median TLC was $99 \times 10^9 / L$ and the median platelet count was $423 \times 10^9 / L$ [Table. 3]. In blast crisis of CML, male predominance (66.6 %) was seen while the mean age was 40 ± 9 years. The mean haemoglobin was 8 g / dL . All the blast crisis cases presented with anaemia out of which 1 case (17 %) had mild anaemia, 3 cases (50 %) had moderate anaemia and 2 cases (33 %) had severe anaemia. The median TLC was $48 \times 10^9 / L$. 83 % had total leucocyte count $> 10 \times 10^9 / L$, while 17 % had $< 10 \times 10^9 / L$. All the blast crisis cases had platelets count $< 100 \times 10^9 / L$ with median platelet count $20.5 \times 10^9 / L$. The mean blast count on differential was 52 % and 72.2 % in peripheral smear and bone marrow aspirate smear respectively. This included 67 % of lymphoid and 33 % myeloid blasts. All the cases with lymphoid blast crisis were of B-cell phenotype which was confirmed by flowcytometry. The blast cells were positive for CD45, CD34, CD10, CD19 and heterogenous for CD20. Molecular study for BCR-ABL1 was done for all the cases, which were all positive. Karyograph detected translocation t (9;22) that lead to the formation of Philadelphia (Ph) chromosome having BCR-ABL1 fusion gene. RQPCR was also done to follow-up in 11 cases (55 %).

BCR-ABL1 Negative MPNs

Amongst the BCR-ABL1 negative MPNs, the mean age was higher in JAK2V617 positive (59 ± 11.2 years) than the JAK2V617 negative (55 ± 19.2 years). The mean haemoglobin was higher in JAK2V617F positive cases ($18.8 \pm 2.5 \text{ g / dL}$) than the negative cases ($15.3 \pm 6.5 \text{ g / dL}$). The median platelet count was also higher in JAK2V617F negative cases ($55 \times 10^9 / L$) than the positive cases ($230 \times 10^9 / L$). These findings show correlation (P value < 0.05). [Table no. 4]

Polycythaemia Vera (PV)

14 patients have been diagnosed as polycythaemia vera with age range of 33 to 70 years, out of which 7 (50 %) were females and 7 (50 %) were male. The mean haemoglobin

was $20.2 \pm 2.17 \text{ g / dL}$, median TLC was $10.3 \times 10^9 / L$ and median platelet count was $435 \times 10^9 / L$. JAK2V617F was positive in 10 (71 %) cases while it was not done in 4 (29 %) cases due to financial problems by the patients. However, these patients fulfilled the WHO criteria for diagnosis. Among the PV, 6 (42.8 %) of the cases were incidental finding while 3 (21.4 %) presented with stroke, 2 (14.2 %) presented with bleeding and 3 (21.4 %) presented with headache. These findings were significant in PV. Splenomegaly was seen in 4 (29 %) cases. Bone marrow examination was done in 8 cases (57 %). Age-adjusted hypercellularity was seen in 6 cases (75 %) while 2 cases (25 %) show normocellular marrow. All the cases show trilineage hyperplasia of all the haematopoietic elements along with pleomorphic megakaryocytes. (Table. 5). These megakaryocytes are arranged in cluster as well as in single in the trephine biopsy section.

Primary Myelofibrosis (PM)

Three cases of primary myelofibrosis were diagnosed, out of which 1 (33 %) was in pre-fibrotic stage whereas 2 (67 %) were in overt-fibrotic stage. Female predominance was seen (67 %). The mean age was 73 ± 7.5 years. 1 case (33 %) had splenomegaly. On complete haemogram, only 33 % (1 out of 3 cases) of PMF presented with severe anaemia with a mean haemoglobin of $9.9 \pm 4.7 \text{ g / dL}$. 1 (33 %) of the cases had TLC more than $100 \times 10^9 / L$, 1 (33 %) with leucopenia. The median TLC was $4.6 \times 10^9 / L$. The median platelet count was $80 \times 10^9 / L$. JAK2V617F mutation was noted in 1 (33 %) case in whom CALR was negative, while another case (33 %) had CALR mutation with absent JAK2V617F mutation. Leucoerythroblastic blood picture including nucleated red blood cells (nRBC), tear drop cells myelocytes and metamyelocytes were observed in 1 case (33 %) with overt-fibrotic stage. Bone marrow examination showed megakaryocyte dysplasia, some with cloud-like nuclei in all the cases. Fibrosis was seen in all the cases [Table. 6]. Extensive fibrosis with dilatation of the sinusoids was observed in overt-fibrotic stage. Reticulin stain was in the range of 2+ to 3+ on a scale of 0 to 3+.

Essential Thrombocythaemia (ET)

Three cases of ET were diagnosed, out of which 1 (33 %) was male and 2 (67 %) were female. The mean age was 71 ± 7.1 years. Splenomegaly was observed in 1 case (33 %) on presentation. The median platelet count was $964 \times 10^9 / L$, mean haemoglobin was $13.4 \pm 1.7 \text{ g / dL}$ and median TLC was $6.6 \times 10^9 / L$. CALR mutation was noted in 2 (67 %) cases which was negative for JAK2V617F and BCR-ABL1 while JAK2V617F was detected in 1 (33 %) CALR mutation and BCR-ABL1 negative case. The bone marrow examination revealed normocellular marrow in 2 (67 %) of the cases [Table. 7]. Megakaryocytic preponderance along with presence megakaryocytic clusters in the paratrabeular region, some deeply lobulated forms (staghorn nuclei) were also observed in all cases.

Juvenile Myelomonocytic Leukaemia (JMML)

1 case of JMML was diagnosed presenting with fever, splenomegaly. On examination she had moderate anaemia (7.6 g / dL), absolute monocytosis with a count of 9.1 x 10⁹ / L and thrombocytopenia (28 x 10⁹ / L. Her peripheral smear and bone marrow aspirate smear revealed blast count of 12 % and 13 % respectively. Bone marrow trephine biopsy showed hypercellular marrow. Increased proliferation of immature cells was also seen. Monosomy 7 was detected in cytogenetics analysis.

Chronic Myelomonocytic Leukaemia (CMML)

1 case of CMML was also diagnosed who presented with fever, splenomegaly and weight loss. He had mild anaemia (10 g / dL), monocytosis (11 % of TLC) and thrombocytopenia (86 x 10⁹ / L). No circulatory blast was seen. Bone marrow blast count 3 % (CMML - 0). Dysplasia of myeloid series was also seen. Cytogenetics analysis could not be done due to financial constraints.

Category	Number of Cases, n (%)
CML	20 (48 %)
PV	14 (33 %)
PMF	3 (7 %)
ET	3 (7 %)
CMML	1 (2.5 %)
JMML	1 (2.5 %)
Total	42

Table 1. Distribution of Cases of Myeloproliferative Neoplasm and Myelodysplastic / Myeloproliferative Neoplasm

Category	CML	PV	PMF	ET
Number of Patients	20	14	3	3
Sex (Male / Female)	13 / 7	7 / 7	1 / 2	1 / 2
Age (Year), Mean ± SD	41 ± 13.7	33 ± 12.7	73 ± 7.5	71 ± 7.1
Haematological Findings				
TLC (x 10 ⁹ / L), Median	77	10.3	4.6	6.6
Hb (g / dl), Mean ± SD	9.6 ± 2.3	20 ± 1.6	9.7 ± 4.7	13.4 ± 1.7
Platelet (x 10 ⁹ / L), Median	277.5	435	80	964
Molecular Findings				
BCR ABL1 (+), n / N (%)	20 / 20 (100 %)	0	0	0
JAK2 V617 (+), n / N (%)	0	10 / 14 (71 %)	2 / 3 (67 %)	1 / 3 (33 %)

Table 2. Distribution of Cases of Myeloproliferative Neoplasm

Category	CML-Chronic Phase	CML-Blast Crisis
Number of Patients	14	6
Sex (Male / Female)	9 / 5	4 / 2
Age (Years), Mean ± SD (Range)	42 ± 15.57 (12 - 65)	40 ± 9 (30 - 55)
TLC (x 10 ⁹ / L), Median (Range)	99 (3.7 - 268)	48 (2.5 - 132)
Hb (g / dL), Mean ± SD	10.3 ± 2.3	8 ± 1.3
Platelets (x 10 ⁹ / L), Median (Range)	42.3 (17 - 100)	20.5 (10-60)
Peripheral Smear Blasts (%), Mean ± SD		52 ± 36
Bone Marrow Blasts (%), Mean ± SD		72.2 ± 19.7
Blast Phenotype Lymphoid Phenotype (%)	NA	67 (B-lymphoid type on flowcytometry)
Myeloid Phenotype (%)	NA	33

Table 3. CML- Chronic Phase and Blast Crisis

Category	JAK2 Positive (n=13)	JAK2 Negative (n=6)	P Value
Age (Year), Mean ± SD	59 ± 11.2	55 ± 19.2	<0.05
Hb (g / dl), Mean ± SD	18.8 ± 2.5	15.3 ± 6.5	<0.05
TLC (x 10 ⁹ / L), Median	15	7.2	.117
Platelets (x 10 ⁹ / L), Median	5.8	2	<0.05

Table 4. Comparison of JAK2 Positive and Negative In BCR-ABL1 Negative MPNs

SD - Standard Deviation; Hb - Haemoglobin; TLC - Total Leukocyte Count; JAK2 - Janus Kinase 2. P value < 0.05 is significant.

Category	Findings	P Value
Number of patients	14	-
Sex (male / female)	7 / 7	-
Age (years), Mean ± SD (Range)	33 ± 12.7 (33-70)	-
Presenting Features		
Splenomegaly, n / N (%)	4 / 14 (29 %)	0.10
Incidental, n / N (%)	6 / 14 (42.8 %)	0.59
Stroke, n / N (%)	3 / 14 (21.4 %)	<0.05
Bleeding, n / N (%)	2 / 14 (14.2 %)	<0.05
Headache, n / N (%)	3 / 14 (21.4 %)	<0.05
Haematological Findings		
TLC (x 10 ⁹ / L), Median (range)	10.3 (6.7 - 35)	-
Hb (g / dL), Mean ± SD	20 ± 1.6	-
Platelets (x 10 ⁹ / L), Median (Range)	435 (119 - 940)	-
Erythropoietin (g / L), Median (Range)	2.6 (1 - 4.8)	-
Cellularity* of Bone Marrow		
Hypercellular	6	75 %
Normocellular	2	25 %
Hypocellular	0	0 %
Trilineage Hyperplasia of Bone Marrow	8	100 %
Pleomorphic Megakaryocytes	8	100 %
Molecular Findings		
JAK2 V617F (+), n / N (%)	10 / 13 (76.9 %)*	-
BCR ABL-1 Mutation	Negative in all	-

Table 5. Polycythaemia Vera

*JAK2 V617F was not done in all the patients. *Bone marrow examination was done in 8 patients. p value<0.05 is significant.

Parameters	Findings
Number of Patients	3
Stage	
Pre-Fibrotic	1 / 3 (33 %)
Overt-Fibrotic	2 / 3 (67 %)
Sex (Male / Female)	1 / 2
Age (Years), Mean ± SD (Range)	73 ± 7.5 (65 - 80)
Presenting Complaints	
Splenomegaly (%)	1 (33 %)
Haematological Findings	
TLC (x 10 ⁹ / L), Median(range)	4.6 (2.8 - 23)
Hb (g / dL), Mean ± SD	9.7 ± 4.7
Platelets (x10 ⁹ / L), Median (range)	80 (53-689)
Cellularity of Bone Marrow	
Hypercellular	1 (33 %)
Hypocellular to Normocellular	2 (67 %)
Dysplastic Megakaryocytes*	3 (100 %)
Fibrosis	3 (100 %)
Reticulin Grading**, Range (2+ to 3+)	2 (67 %)
Molecular Findings	
JAK2 V617F (+), n / N (%)	2 / 3 (67 %)
CALR Mutation (+), n / N (%)	1 / 3 (33 %)
BCR ABL-1 mutation	Negative in all

Table 6. Primary Myelofibrosis

*Increased megakaryocytes, hypo lobulated forms and hyperlobulated forms.

**Reticulin stain was done on 2 cases (67 %). Grading was done on a scale of 0 to 3+ (European consensus on grading of bone marrow fibrosis)

Category	Findings
Number of Patients	3
Sex (Male / Female)	1 / 2
Age (Years), Mean ± SD (Range)	71 ± 7.1 (65 - 70)
Presenting Complaints	
Splenomegaly, n (%)	1 (33 %)
Haematological Findings	
TLC (x 10 ⁹ / L) Median	6.6 (5.7 - 14)
Hb (g / dL), Mean ± SD	13.4 ± 1.7
Platelets (x 10 ⁹ / L), Median	964 (865 - 1400)
Cellularity of Bone Marrow	
Hypercellular	0 (0 %)
Normocellular	3 (100 %)
Hypocellular	0 (0 %)
Deeply Lobulated Megakaryocytes*	3 (100 %)
Molecular Findings	
JAK2 V617F (+), n / N (%)	1 / 3 (33 %)
CALR Mutation (+), n / N (%)	2 / 3 (67 %)
BCR ABL-1 mutation	Negative in all

Table 7. Essential Thrombocythaemia

*Megakaryocytic preponderance with many deeply lobulated nuclei (staghorn nuclei).

DISCUSSION

The incidence of CML was higher than PV, PMF and ET with higher male prevalence. Srour et al stated that PV had the

highest incidence in their study.⁴ The difference might be due to the exclusion of secondary causes of erythrocytosis after the accessibility of JAK2 V617F mutation, different geographical and racial distribution and delay in reporting of PV and ET. The mean age of presentation was slightly higher in PMF.

Chronic Myeloid Leukaemia (CML)

In our study, CML chronic phase constitute the majority (70 %) which can be compared to other studies.^{10,11,12} The increased detection of blast phase at diagnosis in comparison to the European country may be due to the difference in the ethnicity¹³, late detection and affordability of the treatment which led to transformation of the disease to blast phase. Most cases presented with anaemia (78 %). Amongst this, most of them were having mild anaemia (50 %), followed by moderate (14 %) and severe anaemia (14 %). However, this is in contrast to the Bhatti et al study in which most patients have moderate anaemia.¹⁴ The mean haemoglobin is 10.3(g / dl) which is similar to the results of Savage et al.¹⁵ Leukocytosis and thrombocytosis was seen in 93 % and 42.8 % of the case of CML-CP respectively. This is slightly higher than the findings of Kumar et al and Bhatti et al in which thrombocytosis was seen in 26.6 % and 26 % respectively.^{13,14}

Amongst the CML, blast phase was 30 %. Anaemia was seen in all the cases in which majority had moderate anaemia (50 %). Thrombocytopenia was more commonly seen in the cases of blast crisis (100 %) which are comparable to studies of Kumar et al and Bhatti et al.^{13,14} Molecular cytogenetics test for BCR-ABL1 mutation was detected in all the cases (100 %). This is slightly higher than the results of Yaghmaie et al (83 %).¹⁶

BCR-ABL1 Negative MPNs

Amongst the BCR-ABL1 negative MPNs, PV had the highest incidence. There was equal distribution in both males and females (50 %) which slightly differ from another study.¹⁷ PMF had highest mean age of presentation which is comparable to another study.¹⁸ Splenomegaly was seen in 4(29 %) cases of PV, 1(33 %) PMF and 1 (33 %) ET which is slightly lower in comparison with other studies.^{17,19,20} Median platelet count was much higher in ET than PV and PMF. These findings are comparable to a German study.²¹ JAK2V617F detection amongst all the BCR-ABL1 negative MPNs was similar to Sazawal et al and Suksomyos et al studies (68 % and 68.8 % respectively).^{20,22} In comparison to JAK2V617F negative cases, JAK2V617F positive cases are associated with higher haemoglobin and higher age, similar to another study.¹⁸ It is interesting to note that CALR mutation in JAK2V617F negative PMF and ET is higher in our study in comparison to other studies which had 25 % to 30 % of PMF and 20 % to 25 % of ET cases. These suggest that in JAK2V617F negative PMF and ET, CALR mutations are most common and these mutations are mutually exclusive of each other.^{23,24,25,26,27} Association of leucoerythroblastic blood picture in PMF (fibrotic stage) is lower compared to another study.¹⁸ Bone marrow

morphology in these disease are in accordance with the typical features BCR-ABL1 negative MPNs. These are similar to another study.¹⁸ This suggest that megakaryocyte morphology is important in determining the diagnosis.

Myelodysplastic / Myeloproliferative Neoplasm

In our series, 1 case of JMML was seen in a 9 years old girl. Other studies found the median age of <1 year with a male preponderance.⁴ However, the haematological findings in our case were in concordance with other study.²⁸ We also had a case of CMML in 42 year old male which is lower than the median age of presentation reported in other study.⁴ The differences may reflect the small sample size of our study.

CONCLUSIONS

This study was done to assess the clinico haematological profile of MPN & MPN / MDS diagnosed in our institute & compare with the findings of other regions to determine as to whether there are any differences or not. There are very few studies assessing the same in our region. In our study, we found substantial differences compared to other studies.

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