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Reliability of the Erythrocyte Sedimentation Rate in General Practice

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Because of the need for an accurate determination of the erythrocyte sedimentation rate (ESR), and because of the fact that many general practitioners frequently determine ESR in their own surgery, we investigated the reliability of the blood test in this setting. For this purpose, blood samples, obtained from the local hospital laboratory, were distributed, and the participating general practice centres were requested to determine ESR in each sample. A clinically important intra– and interpractice variability was found in the ESR values measured. The experiment was then repeated one year later under more standardized conditions, which resulted in a significant decrease in the intra– and interpractice variability ($p = 0.04$ and 0.003, respectively). Vibrations within the hospital building could not account for the systematically higher ESR values measured in the hospital laboratory.

We conclude that a considerable increase in the quality of ESR performance in general practice can be achieved by means of relatively simple interventions.

Key words: erythrocyte sedimentation rate, reliability, intervention study, general practice.

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The determination of the erythrocyte sedimentation rate (ESR) is a frequently used blood test in assessing diagnoses both in general practice (1) and in the hospital (2). We decided to investigate the reliability of ESR, being an important aspect of its diagnostic value. One commonly used way to perform the test is Westergren's method (3). International standards for this method must be met accurately (3). The use of correct techniques (4) and careful handling (5) should be regarded as important in performing any laboratory test. A study of the error rate in physicians' office laboratories recently emphasized this (6), and it is important to note the less comprehensive quality control in general practice laboratories (7). A large inter-practice variability in measured ESR values was found among primary health care centres in Oslo (8). ESR, often regarded as a non-specific indicator for pathology in general practice, may point in the wrong direction if it is not reliably performed. This may result in missing occult but possibly important pathology, or initiating unnecessary investigations.

Our study focussed on the intra– and interpractice variability, and compared ESR measured in general practice with ESR measured in a reference laboratory. Furthermore, we investigated the effect of intervention in decreasing the analytical variability, and finally we considered the possible causes of the systematic deviation at the reference laboratory. Reliability will be defined as the degree of correspondence among several ESR measurements in the same blood sample at the same time in one or several general practice centres (intra- and interpractice variability, respectively).

METHODS

Five general practice centres (GPCs) and the local hospital laboratory ("the laboratory") participated. Two experiments were carried out successively.

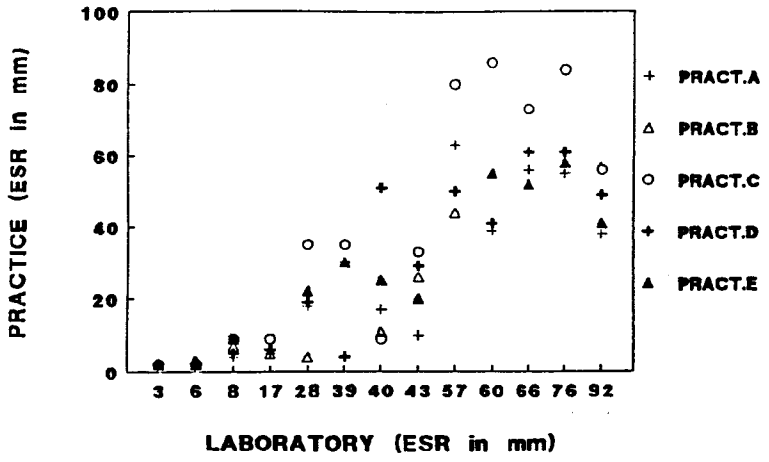

Fig. 1. Correlation between erythrocyte sedimentation rates (ESR) measured in the hospital laboratory (horizontal axis) and in the general practice centres (vertical axis) in 1987. The inter-practice variability can be read from the vertical axis. ESR in mm/h, according to Westergren.

Experiment I

Centrally prepared blood samples, obtained from the laboratory, were distributed by car on 17 different days during April and May 1987. ESR was determined in each sample presented, both in the GPCs and at the laboratory. The test was performed as usual without specific instructions being given. Each GPC used its own determination equipment. By using several blood sample pairs, each pair consisting of two samples of blood coming from one person, both intra- and interpractice variability could be assessed. Per delivery 3 or 5 blood samples were presented, including one and two pairs, respectively.

Experiment II

The second experiment was undertaken one year later, during April and May 1988. It was preceded by detailed instructions to each GPC about all important technical aspects of ESR determinations. Furthermore, all GPCs were supplied from the laboratory with the same type of ESR determination-equipment (Sterilin holding devices, Continental Pharma, Zutphen, The Netherlands), including disposable tubes (Omnilabo, Breda, The Netherlands, serial number 203001). Again, centrally prepared blood samples (and -pairs) were distributed, and the ESR determinations were carried out without any delay. Series of 5 samples were used. The fifth, so-called dummy sample was involved in the inter-practice reliability study.

Procedures and additional exploration

To prevent clotting, the blood was collected in ethylenediaminetetra acid (EDTA-K3) tubes. After the sample drawing, the distribution took place within

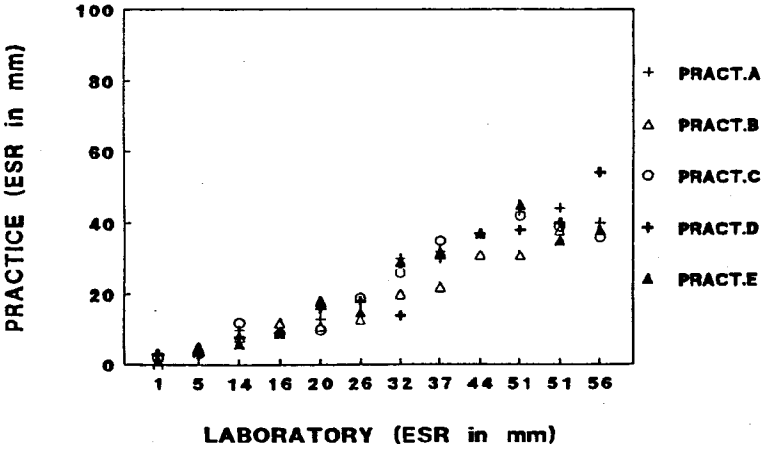

Fig. 2. Correlation between the erythrocyte sedimentation rates (ESR) measured in the hospital laboratory (horizontal axis) and in the general practice centres (vertical axis) in 1988. The inter-practice variability can be read from the vertical axis. ESR in mm/h, according to Westergren.

Table. 1. *Intra-practice variability of blood sample pairs in 1987. The erythrocyte sedimentation rates (ESR), as measured within each pair, are listed according to the sequence in which the pairs were offered at each general practice centre (GPC). The coefficient of variation (CV) was calculated for each pair.*

GPC	ESR in mm/h, according to Westergren		
	Measurement 1	Measurement 2	CV(%)
A	4	33	111
	6	6	0
	28	34	14
B	16	11	26
	79	116	27
	38	26	27
	2	2	0
C	40	54	21
	122	115	4
	6	7	11
	2	2	0
D	110	115	3
	4	3	20
	2	3	28
	106	85	16
E	7	10	25
	3	4	20
	18	8	54
	18	3	101

four hours, during which the samples were stored in a refrigarator. The GPCs were visited in a different sequence each time. The performance of ESR determinations was closely observed several times in each GPC. During the experiments, the GPCs were not informed about the values measured by the others, including the laboratory. For the additional exploration ESR was measured simultaneously in the laboratory on the third floor and in the blood donor centre on the ground floor of the hospital building.

Statistical analysis

While blood samples with higher mean ESR values will partially account for increased ranges in the ESR values measured in the GPCs, the coefficient of variation (CV) can be regarded as an acceptable standard in the analysis of these ranges. After we had calculated all CVs for the intra- and interpractice reliability, we compared the differences in CVs between the first and the second experiment by means of Wilcoxon's distribution free tests for dependent and independent samples (Signed Rank and Rank Sum Test, respectively). Pearson's product moment correlation coefficient and the regression coefficient with its 95% confidence interval were used in the analysis of the validity of the ESR values measured in the GPCs compared with those measured in the laboratory.

RESULTS

Experiments I and II will be reported in combination, focussing on the intra- and interpractice variability and the effect of intervention.

Table 2. *Intra-practice variability of blood sample pairs in 1988. Erythrocyte sedimentation rates (ESR), as measured within each pair, are listed according to the sequence in which pairs were offered at each general practice centre (GPC). The coefficient of variation (CV) was calculated for each pair.*

GPC	ESR in mm/h, according to Westergren		
	Measurement 1	Measurement 2	CV(%)
A	106	106	0
	11	13	12
	8	9	8
	37	38	2
	41	40	2
	59	61	2
B	107	103	3
	11	13	12
	5	5	0
C	118	111	4
	11	10	7
	4	4	0
	36	38	4
	46	46	0
D	119	133	8
	12	14	11
	3	7	57
	31	33	4
	46	45	2
	74	69	5
E	109	95	10
	11	12	6
	6	8	20
	33	37	8
	33	36	6
	50	54	5

Interpractice variability

The results are shown in Figures 1 and 2. The Figures show the range of ESR vallues measured in the GPCs, in relation to the values measured in the laboratory. The laboratory values are depicted on the horizontal axis, and for practical purposes the distance between two values is kept equal. As a result of holiday and accidental sample mismanagement, there were nine cases in which ESR could be measured in only four GPCs. From the data in Figures 1 and 2, the correlation coefficients between the laboratory results and the GPC results were calculated as .83 ($p < 0.001$) and .97 ($p < 0.001$), while the regression coefficients were .76 (intercept −1.13) and .79 (intercept −1.04) respectively. The 95% confidence intervals of the regression coefficients were .63−.89 and .73−.85.

In five cases in 1988 the laboratory accidentally performed ESR measurements incorrectly. Accordingly, these values are not included in Figures 1 and 2, nor have they been used in the calculations above. However, in these five cases all GPCs performed ESR measurements properly, so CVs could still be assessed and used in the overall calculations.

Testing the difference in variability between 1987 and 1988, using the Rank Sum Test, resulted in a 0.003 level of significance.

Intrapractice variability

The results can be seen from Tables 1 and 2. In 1988 each GPC received two sample pairs more than in 1987. Differences between the numbers of sample pairs per GPC are due to holiday and accidental sample mismanagement. A mean CV was calculated for each GPC for 1987 and 1988. The intra-practice difference between the mean CVs of 1987 and 1988 was analysed using the Signed Rank Test, which resulted in a 0.04 level of significance.

Observations and additional exploration

In 1987 only GPC C used disposable sedimentation tubes, whereas the remaining GPCs did not always use properly cleaned non-disposable tubes (cleaning with water only). In three GPCs (A, B, E) a urinesample centrifuge was situated not far from the sedimentation tube holding device. In 1988 this was changed, so that centrifuge vibrations could not influence ESR measurements any more. In both years, all determinations were carried out by trained personnel, in accordance with Westergren's method. Apart from the factors mentioned above, the recommendations for correct performance (3) were followed.

The results of the additional study showed no systematic difference in ESR values measured either on the ground floor or on the third floor of the hospital building. The correlation coefficient was calculated as .99 ($p < 0.001$) and the regression coefficient as 1.08 (95% confidence interval .98−1.17, intercept −.06).

DISCUSSION

The finding of a considerable variability in daily practice is in agreement with the Norwegian study on this topic (8). However, we have shown that this can be substantially reduced by improving test management.

As can be seen from Figure 1, the range in ESR values measured before the intervention increases with higher laboratory values. This finding is of clinical importance with reference to laboratory values between approximately 20 and 60 mm. For example, in the blood sample with an ESR of 40 mm as measured in the laboratory, the ESRs measured in the GPCs varied from 9 to 51 mm. Whereas in general an ESR of 9 mm may be considered normal, 51 mm will be regarded as high, and quite different clinical policies might be the result in the two cases. Similar conclusions can be drawn from the ESR values in Table 1. For example, in one blood sample pair with a mean ESR of 19 mm GPC A measured ESR values of 4 and 33 mm. Again, 4 mm may be regarded as normal and 33 mm as high (depending on the patients' age). These results may even be relatively optimistic, because the knowledge of cooperating in a scientific experiment might already have resulted in a more accurate execution of ESR measurements.

After the intervention, Figure 2 and Table 2 show a significant decrease in the variability, which is now no longer clinically important. Hence, the intervention on technical aspects of the ESR measurements can be regarded as successful. One may question which aspect in particular will have accounted for this success. From the observations during the first experiment it was suggested that the use of improperly cleaned sedimentation tubes could largely be held responsible for the initial variability. This conclusion was supported by the almost systematically higher ESR values measured by GPC C, the only

GPC that used disposable tubes at the time. The plastic material of which such tubes are constructed may have partially accounted for this, since plastic is possibly smoother than glass. However, after the second experiment the use of disposable glass tubes resulted in a decrease of the mean CV in GPC C as well.

The position of the holding device, not far from a potentially vibrating urine sample centrifuge, may have contributed to the variability in the first experiment as well. But the centrifuge will have been functioning simultaneously with an ESR determination only very occasionally. A third aspect of the decrease in variability may have been the absence of a time delay in the execution of ESR measurements during the second experiment. However, only a limited delay (always within 150 minutes) occurred during the first experiment, and that only in a very few cases.

We conclude that the use of properly cleaned sedimentation rate tubes is an aspect of major importance in the correct execution of ESR determination.

Whereas the regression coefficients differed only slightly in the first and second experiment, general practitioners seem to underestimate higher ESR: with increasing ESR values measured in the laboratory, the GPCs determined relatively lower ESRs.

The correlation coefficient clearly increased after the second experiment. This means that the intervention not only decreased the variability, but an increase in conformity between measured ESR values and laboratory values resulted as well. Figures 1 and 2 show laboratory values which are systematically higher than measured ESRs. After the second experiment this is even more explicit. We suggested that a more or less persistent vibration within the laboratory on the third floor of the hospital building may have influenced ESR measurements. The additional investigation was therefore undertaken. The results of this experiment however imply that correction for any such vibration effects would not diminish the difference in ESR values between the laboratory and the GPCs. One might suppose that the blood sample transportation by car may have influenced the ESR values measured. But, after investigating this aspect separately (9), we were able to reject this hypothesis. Whereas we considered it to be inappropriate to investigate further the intralaboratory variability, we conclude that we could find no satisfactory explanation for the higher ESR values measured in the hospital laboratory.

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