

Reprinted article
Vol. 25, Issue 5/6, 2001

**Comparison of Manual vs. Automated Blood Sedimentation
Test: Quality and Economy**

Comparison of Manual vs. Automated Blood Sedimentation Test: Quality and Economy

Vergleich manueller vs. automatisierter ESR: Qualität und Ökonomie

P. Koch¹, Annemarie Bitterli¹, Armina Alunsagay², A. Huber².

Summary: The blood sedimentation rate (ESR = Erythrocytes sedimentation rate) is used as a non-specific screening assay for inflammatory processes as well as for monitoring therapy. A new generation of instruments enables a fully automated, centralised ESR testing instead of the manual testing of individual samples on the wards. Two ESR instruments were evaluated for quality of results, efficiency, cost, and relief given to the ward staff. The instruments from Becton-Dickinson (BD aut) and Greiner (G aut) were tested at two separate hospitals. Data obtained were compared to the manually measured results and to the Westergren standard method (WG). Concordance (K), discordance (D), and precision (CV) of the instrument measurements were determined. Further, the linear regression (Passing-Bablok) of the manual measurements in comparison with the automatic measurements yielded the following: G man vs. G aut: $y = 1.00x + 0.00$ ($r = 0.996$) and BD man vs. BD aut: $y = 0.91x - 4.81$ ($r = 0.977$). In addition, correlation with the Westergren method was: G aut vs. WG: $y = 1.24x - 0.06$ ($r = 0.983$), and BD aut vs. WG: $y = 1.06x + 11.29$ ($r = 0.942$). The CV at elevated sedimentation rates was 9.0 % and 9.1 % for G aut and BD aut, respectively. The D (manual system used as "gold standard") was 100 % for G aut and 87.2 % for BD aut. The K obtained was 92.3 % for G aut (100 %, BD aut). Furthermore, both instruments revealed an excellent correlation with the data obtained by the classic WG method. After recalibration, the BD aut showed very good results. The automatic measurements enable high precision and guarantee stable measuring conditions. Further, online connection to the laboratory information system allows the rapid transmission, billing, and traceability of results, all of which are required in a modern TQM-dependent lab. The ward staff appreciated the extra time gained to dedicate to patient care.

Keywords: blood sedimentation test; inflammation.

Zusammenfassung: Die Blutsenkungsrate (ESR) dient als unspezifisches Suchverfahren bei Verdacht auf entzündliche Reaktionen sowie zu deren Verlaufsbeurteilung. Neuere Geräte ermöglichen die vollautomatische, zentrale Durchführung der ESR, die bisher üblicherweise dezentral auf Stationen durchgeführt wurde. Zwei ESR-Geräte wurden bezüglich Qualität der Resultate, Praktika-

bilität, Kosten und Entlastung der Stationen evaluiert. An zwei Spitälern wurden Geräte von Becton-Dickinson (BD aut) und Greiner (G aut) getestet. Die Automatenwerte wurden gegen manuell gemessene Resultate und gegen den Westergren-Standard (WG) verglichen. Gegenüber der manuellen Messung wurde die Diskordanz (D) und Konkordanz (K) der Gerätemessung, sowie die Präzision (VK) bestimmt. Die Korrelationsgerade nach Passing-Bablok der manuellen gegen die automatisierte Messung ergab: G man vs. G aut: $y = 1,00x + 0,00$ ($r = 0,996$) bzw. BD man vs. BD aut: $y = 0,91x - 4,81$ ($r = 0,977$). Die Resultate der Automaten gegen den (WG) zeigten: G aut vs. WG: $y = 1,24x - 0,06$ ($r = 0,983$) bzw. BD aut vs. WG: $y = 1,06x + 11,29$ ($r = 0,942$). Der VK beträgt bei erhöhten Werten für G aut: 9,0 % und für BD aut 9,1 %. Die D mit dem manuellen System als Basis, beträgt beim G aut: 100 % (BD aut: 87,2 % *vor Rekalibrierung), die K: G aut 92,3 % (BD aut 100 %). Beide Geräte zeigen eine ausgezeichnete Korrelation zu den manuellen Werten und gegen den WG. Nach Rekalibration war auch der Achsenabschnitt beim BD aut deutlich korrigiert. Die Automatisierung der Messung ermöglicht eine hohe Präzision und garantiert stabile Messbedingungen. Die stets gewarteten Geräte sind online an der Labor-EDV, was u.a. auch die Rückverfolgbarkeit der Resultate sichert. Die Stationen schätzen die Entlastung und können sich der Pflege widmen.

Schlüsselwörter: ESR; Blutsenkungsrate; Entzündung.

The erythrocytes sedimentation rate (ESR) is one of the most frequently prescribed laboratory tests. It is useful as a non-specific screening assay for inflammatory processes as well as for monitoring therapy [1–3]. The surface of erythrocytes is negatively charged so that these cells repel each other [1]. During inflammatory processes, the plasma concentration of α -globulin, acute-phase proteins, and fibrinogen increases, promoting aggregation of the erythrocytes in spherical formations with a greater mass to surface area and thus a more rapid sedimentation [1]. Although several, more specific inflammatory markers can now be readily determined, the ESR maintains its important role. The best known and most implemented inflammatory marker, the C-reactive protein (CRP), is useful for the determination of middle to severe, mostly bacterial, infections as well as for monitoring therapy, especially with antibiotics [2, 3]. Further parameters, some of a specific nature, are serum amyloid A, various interleukines, neopterin, procalcitonin, and the tumor necrosis factor. However, these markers have yet to be incorporated in routine diagnostics

¹Zentrallabor, Stadtspital Waid, Zürich (SWZ),

²Zentrum für Labormedizin, Kantonsspital, Aarau (KSA)

Correspondence:

Prof. Dr. med. Andreas Huber, Zentrum für Labormedizin
Kantonsspital Aarau, 5000 Aarau, Switzerland
Tel. +41-62-838 53 02, Fax +41-62-838 53 99

Received: 16. Februar 2001 / Accepted: 07. März 2001

and are only performed in specific clinical situations (transplant rejection, allergic inflammation, patients with immune suppression and autoimmune diseases). The inflammatory reaction is not specific to these parameters. Apart from the lack of specificity, quantitative aspects are of importance. The synthesis of these markers is dependent not only on the type and extent of the infection or inflammation but also from the state of the tissue synthesising the marker. This can be seen, for example, in CRP, which is produced as a secondary inflammatory marker by cytokine stimulation of liver cells and then released into the circulatory system. Thus, immune suppression, liver damage, and other factors influence its presence. Furthermore, chronic and temporal infections usually lead to little or no increase in CRP. The ESR is the least specific assay for inflammatory processes, but therein lies its strength. Increased values can be found, at the earliest, 24 h after the onset of the inflammatory process, also by virus infections, chronic infections, tumors, and autoimmune diseases. Since the ESR is dependent on many factors, such as variations in plasma proteins, clotting factors, and changes in the erythrocytes, not only inflammatory processes but also hematological diseases such as hemolysis, multiple myeloma, autoimmune antibodies, allo antibodies, etc. can be detected [2, 3]. On admission and during the period of hospitalization, blood samples for laboratory analysis are usually taken by the ward staff and then transported to the laboratory where the analyses are performed and recorded. This course of events guarantees the required quality control, documentation and traceability of results. Few laboratory analyses are carried out at the patient's bedside (point-of-care testing, POCT) by personnel without laboratory training. These include the determination of capillary glucose and sometimes urine analysis with test sticks and the Quick capillary clotting test. This is often the case when the patient must learn to perform these tests during the hospitalisation period in order to perform them independently on release. Traditionally, ESR is determined decentrally by the ward staff. Factors such as insufficient mixing, tilted sedimentation tubes, length of storage, temperature (sunlight, radiator, open window), as well as incorrect times of reading times (stop-watch overheard, no time to take the reading) are sources of error. Furthermore, the necessary documentation in the laboratory-EDP or patient's file and the traceability for billing are not ensured. For these reasons we investigated the effect of centralising the ESR on staff workload and the precision of the automated methods.

Materials and Methods

About 400 blood sedimentation rate were compared. Evaluation of the automated ESR analyzers was performed at two centres: Sedisystem von Becton-Dickinson (BD aut) in KSA and Sed Rate Screener von Greiner (G aut) in SWZ. Whereas in Sedisystem the samples are determined in batches, a random start is possible for each sample with Sed Rate Screener. For each sample the ESR test-tubes were read manually in the rack provided by the manufacturer and determined with the corresponding automatic analyzer, and the values compared. Similarly, samples were determined by the ESR analyzer and by the standard, Westergren method. The samples originated from a cross-section of patients (emergency room, rheumatology clinic, outpatients, and internal medicine). After correct sampling by unrestricted venipuncture and immediate transportation to the laboratory, blood samples were placed on a mixer for 5 min. The sedimentation reaction was carried out according to the manufacturer's instructions (BD or G). Whereas for the manual method with the respective racks (BD or G) results must be read after one hour, with Sedisystem (BD) and Sed Rate Screener (G) readings could be taken after 20 or 30 min, respectively and extrapolated. The statistical analysis was performed by linear regression. Correlations were determined by the Passing-Bablok (PB) procedure for testing the equality of measurements from two different analytical methods [4].

Results

The comparison of measurements ($n = 212$) between Seditainer (manual) and Sedisystem (automatic) can be seen in Figure 1. Statistical analysis according to PB gave a correlation coefficient of $r = 0.977$, the regression line was $y = 0.91x - 4.81$. Analog, the comparisons in Figure 2 between the Greiner manual and Greiner Sed Rate Screener ($n = 126$) were $y = 1.00x + 0.00$ and $r = 0.996$. In Figure 3a, the correlation between Sedisystem and the Westergren standard method is shown ($n = 20$): $r = 0.942$ and $y = 1.06x + 11.29$. Additionally, the values from Seditainer (manual) were compared to Westergren: $y = 1.09x + 2.69$ with $r = 0.973$ (Fig. 3b). Comparison of results ($n = 50$) from Greiner automatic analyzer with Westergren (Fig. 4) shows $y = 1.24x - 0.06$ and $r = 0.983$. The precision (CV) by increased values for Greiner aut lies by 9.0 % and for BD aut by 9.1 %. For values within the reference range, the CV for

Table 1 Statistical analyses of comparisons of values from automatic determinations and manual readings or the Westergren method.

	Regression line	r
Greiner, manual (x) vs. Sed Rate Screener (y)	$y = 1.00x + 0.00$	0.996
Seditainer, manual (x) vs. Sedisystem (y)	$y = 0.91x - 4.81$	0.977
Greiner Sed Rate Screener (x) vs. Westergren (y)	$y = 1.24x - 0.06$	0.983
Sedisystem (x) vs. Westergren (y)	$y = 1.06x + 11.29$	0.942
Seditainer (x) vs. Westergren (y)	$y = 1.09x + 2.69$	0.973

both apparatus was 4 %. This would also explain outliers within the statistical scatter. In summary, it can be said that with regard to the intra- and inter-run precision, correlations between the automated systems and the manual methods are excellent. The comparison with the traditional, Westergren standard method confirmed that both automated methods lead to valid results. Based on the data from the Greiner manual method, the concordance was – with 3 wrongly positive values (n = 126) – 92.3 % for Sed Rate Screener. The discordance was 100 % (Fig. 5). The concordance of Sedisystem compared to Seditainer (Fig. 6) was 100 %: the discordance 87.2 % (26 wrongly positive results n = 212). For this reason, the Sedisystem was recalibrated, after which a good axis intercept was found.

Procedure

In both KSA and SWZ, the ESR sample tubes, often together with other sample tubes from the same patient, were sent with a machine-readable order form by

pneumatic dispatch system to the central laboratory. The order form was automatically read and the tubes labelled with a bar code. The bar code was read by a hand scanner at the ESR apparatus, and the sample tubes were placed consecutively in one of the 100 measuring positions. After 30 min, the result was transmitted online to the laboratory’s EDP-System, where it was validated and the result printed in the patient’s hematological diagnosis sheet. The documentation ensured traceability for billing purposes. The workload relief was greatly appreciated by the emergency room and ward staff.

Discussion

The ESR maintains its role for screening purposes as well as a follow-up at certain intervals of specific chronic diseases. The determination of acute-phase proteins, such as CRP, complements the ESR. According to the quality control guidelines valid in most European countries (e.g. EN 45001, ISO 17025) and the USA (NCCLS), the determination of ESR must be quality controlled,

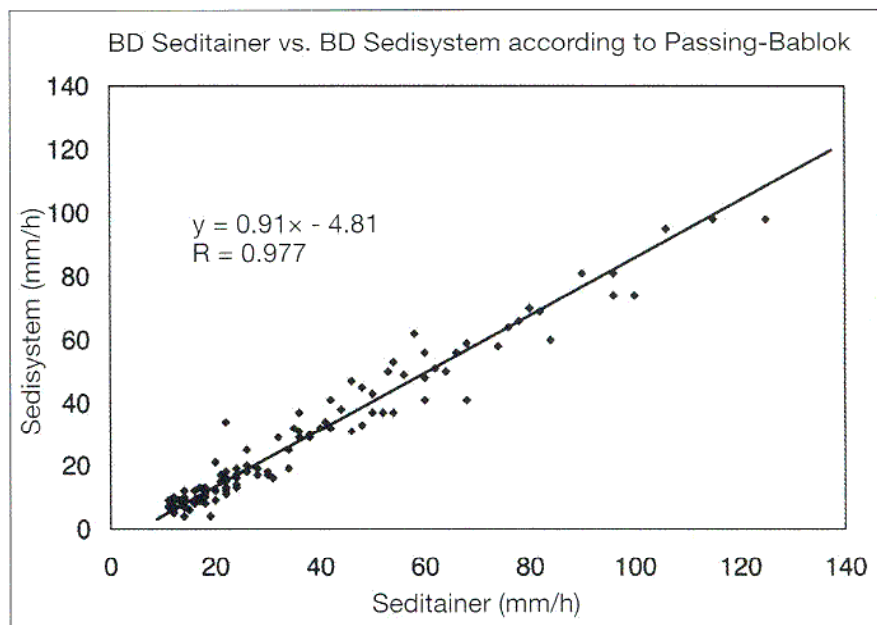


Figure 1 The analysis shows a clear axis displacement by an otherwise good correlation (r = 0.977).

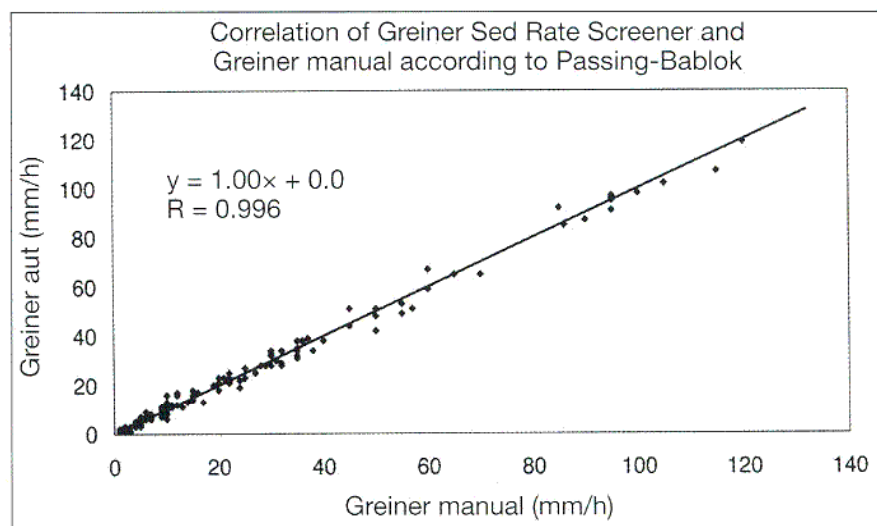


Figure 2 The regression line shows an excellent correlation of the measured values (r = 0.996).

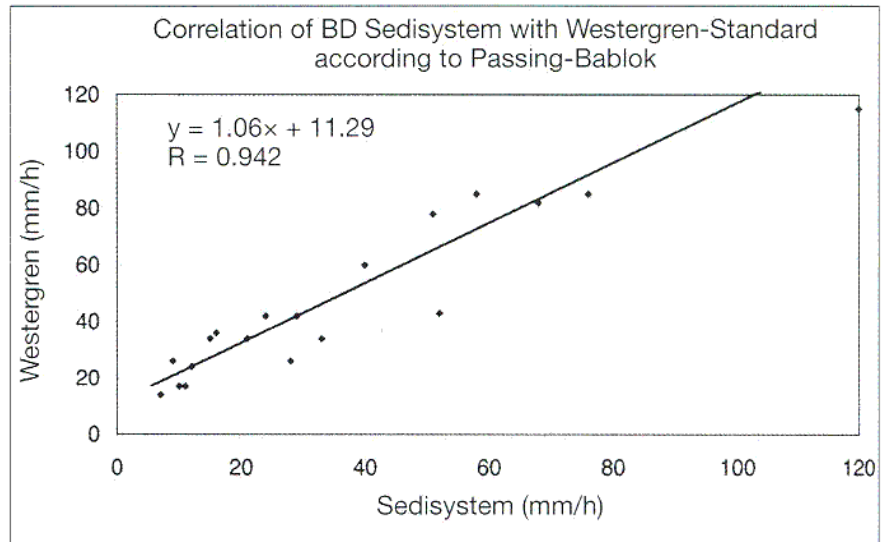


Figure 3a The correlation analysis revealed a much too high axis intercept (11.29). The system was subsequently recalibrated.

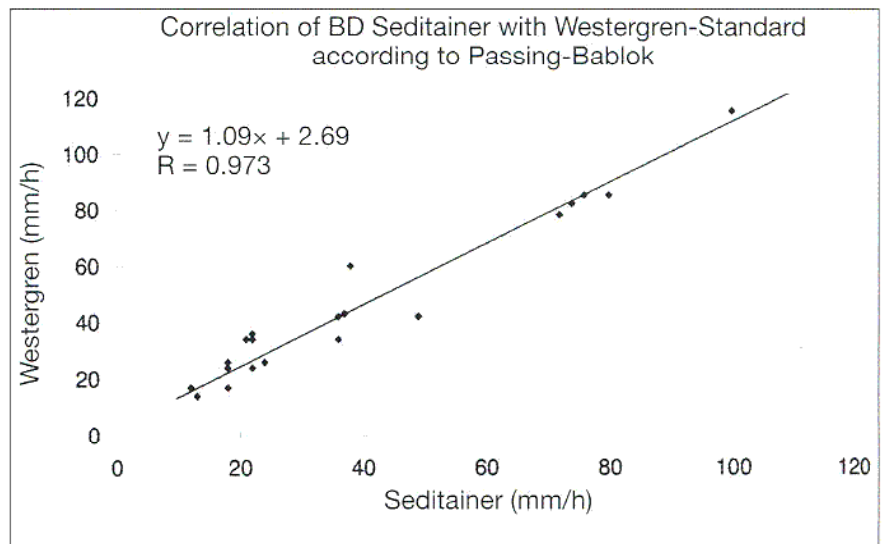


Figure 3b The regression line has a good slope (1.09). The axis is clearly displaced with an intercept of 2.69.

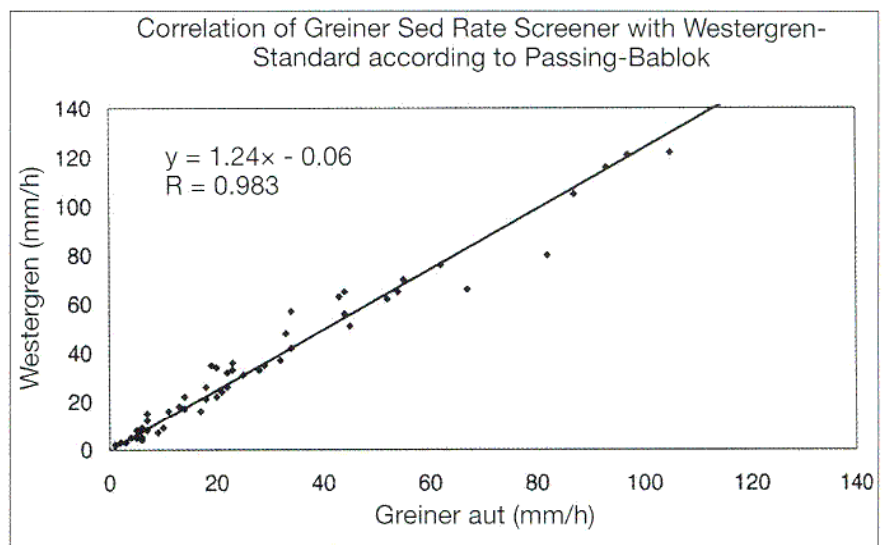


Figure 4 The analysis shows a good correlation ($r = 0.983$) and a slope of 1.24.

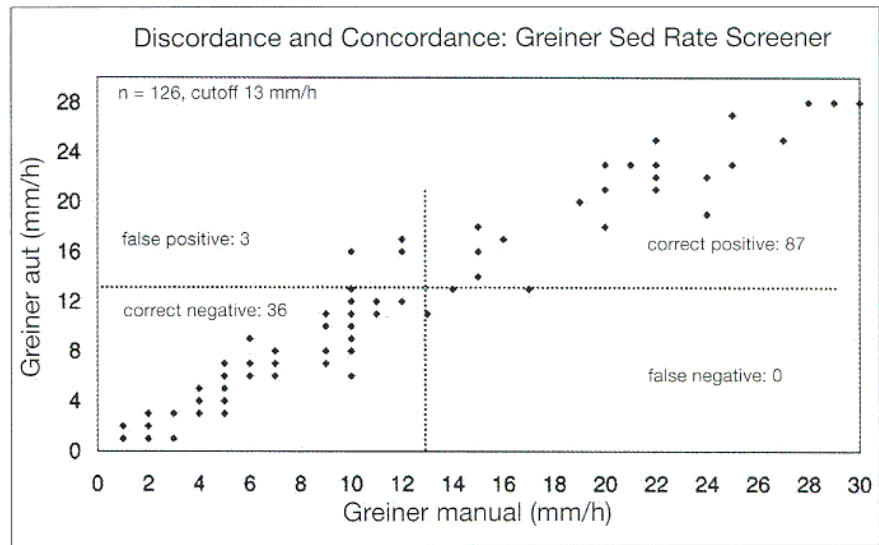


Figure 5 Greiner Sed Rate Screener: Cutoff 13 mm/h, n = 126. Discordance = correct positive results (87) / (correct positive results [87] + false negative results [0]) = 100 %. Concordance = correct negative results (36) / (correct negative results [36] + false positive results [3]) = 92.3 %.

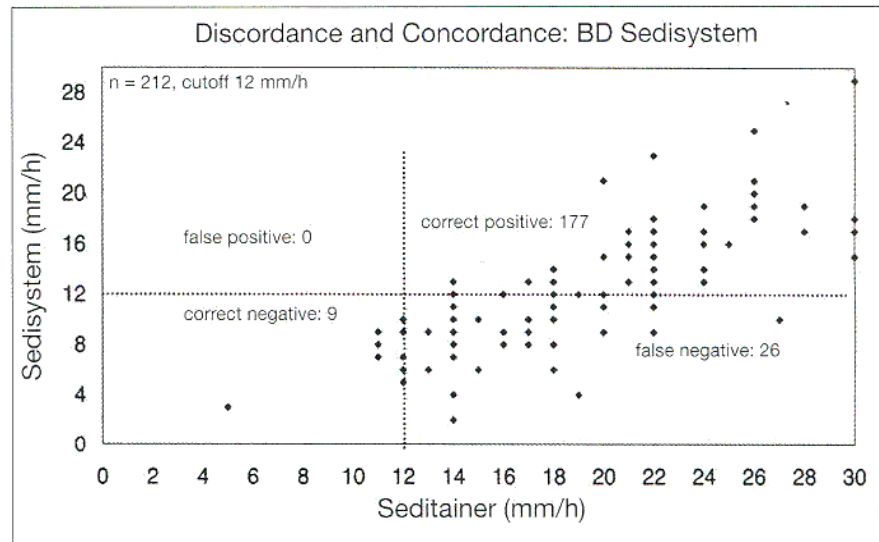


Figure 6 BD Sedisystem: Cutoff 12 mm/h, n = 212. Discordance = correct positive results (177) / (correct positive results [177] + false negative results [26]) = 87.2%. Concordance = correct negative results (9) / (correct negative results [9] + false positive results [0]) = 100%.

Table 2 Discordance, concordance, and precision of Sedisystem (BD) and Sed Rate Screener (Greiner). Analysis of results from Figures 5 and 6.

Apparatus	n	correct positive	correct negative	wrongly positive	wrongly negative	discordance (D)	concordance (K)	VK (for elevated values)
Sed Rate Screener	126	87	36	3	0	100 %	92,3 %	9,1 %
Sedisystem*	212	177	9	0	26	87,2 %	100 %	9,0 %

* before recalibration.

standardised, and retraceable. With the increasing need for cost-efficiency in the health services, total costs must be taken into account. These include not only material costs (e.g. blood sample tubes) but also costs for equipment and especially personnel. The determination of ESR by ward staff is time-consuming, interrupts regular nursing duties, and is relatively expensive. Although not analysed in our small study, it can be assumed that

decentrally performed laboratory analyses have a higher rate of error. Even by a simple test such as ESR, this can lead to further analyses, false therapy, and increased costs. A cost-effective solution complying with quality control guidelines and providing relief for the ward staff was found in KSA and SWZ by reorganizing the ESR. Most of the pre-analytic problems were solved and a reduction in the administrative workload by excellent

precision was achieved, since the results are transmitted online to the laboratory EDP-System, thereby ensuring traceability. Our study shows that a thorough evaluation is useful, even for simple tests, to obviate errors in instrument calibration and to determine the precision of the method to ensure that further investigations are on the right course.

Literature

1. Fabry Th L. Mechanism of Erythrocyte Aggregation and Sedimentation. *Blood* 1987;70 (5):1572-6.
2. Reinhart WH. Die Blutsenkung – ein einfacher und nützlicher Test? *Schweiz Med Wschr* 1988;118: 839-44.
3. Thomas L. Blutkörperchensenkungsreaktion. In: Thomas L, editor. *Labor und Diagnose Indikation und Bewertung von Laborbefunden für die medizinische Diagnostik*. Frankfurt /M (Deutschland): TH-Books Verlagsgesellschaft, 1998:715-6.
4. Passing H, Bablok W. A New Biometrical Procedure for Testing the Equality of Measurements from Two Different Analytical Methods. *J Clin Chem Biochem* 1983;21:709-20.