A cross-sectional study to compare two blood collection methods: direct venous puncture and peripheral venous catheter

Nativitat Ortells-Abuye,1 Teresa Busquets-Puigdevall,2 Maribel Díaz-Bergara,2 Marta Paguina-Marcos,1 Inma Sánchez-Pérez3

ABSTRACT

Objectives: To demonstrate the equivalence between blood collection methods using direct venous puncture (DVP) and a peripheral venous catheter or cannula (PVC).

Design and setting: A cross-sectional study of simple crossover design with within-subject measures carried out between October 2011 and May 2012 at a regional hospital in Spain.

Participants: 272 patients aged 18 or older hospitalised or admitted to the short-stay unit (SSU) who required laboratory testing and PVC to administer saline solution, intravenous fluid therapy and/or intravenous medication. Excluded were those with PVC collection time exceeding 20 s, difficulty of venoclysis, or who presented with arteriovenous fistula, language difficulties, in critical condition or altered consciousness with no family to consent.

Primary and secondary outcome measures: 18 variables were recorded for DVP and PVC, along with age, sex, diagnosis, vein location for DVP, location of the PVC, PVC calibre, saline syringe, intravenous fluid therapy, medication, haemolysis and clotted blood during DVP or PVC collection. Univariate analysis, Pearson’s product-moment fluidity coefficient (r), Lin’s concordance correlation coefficient ($c_r$) and Bland-Altman’s 95% agreement interval were provided.

Results: Included in the study were 272 patients, primarily aged 65 or older (80.9%), males (52.6%) and receiving intermittent medication (43.4%). Values obtained with both methods showed a positive linear association, being moderate for $pO_2$ ($r=0.405$) and very high for all others ($r>0.86$). Levels were concordant ($r_c≥0.9$), except for calcium ($r_c=0.860$), pH ($r_c=0.853$), $pCO_2$ ($r_c=0.843$) and $pO_2$ ($r_c=0.336$) and equivalent for all determinations except $pCO_2$ and $pO_2$, where clinically significant differences were found in more than 9% of cases (21.2%, 95% CI 16.6% to 26.5% and 73.1%, 95% CI 67.4% to 78.1%).

Conclusions: Blood collection methods using DVP and PVC can be used interchangeably for most routine laboratory tests.

INTRODUCTION

Hospitalised patients are subjected to various invasive techniques during hospital stay. One of the most common is direct venous puncture (DVP) or phlebotomy, to obtain blood samples and be able to monitor and control their disease.

The many punctures or venoclyses, sometimes made daily, may provoke anxiety, acute pain and stress.1 2 Moreover, they pose a risk of altered skin integrity and may degrade peripheral circulation in the upper limbs and create difficulty for reinsertion of new peripheral venous catheters or cannulas (PVC) of about 3–5 cm in length for administration of intravenous medication necessary when phlebitis or extravasations occur that require removal of the affected catheters and circulatory treatment for venous insufficiency.

Obtaining blood samples using PVC would improve treatment quality while reducing use of traumatic techniques and risk to the nursing staff of accidental needlestick injuries.

Professional staff requesting laboratory testing at the hospital where this study was conducted usually preferred collection using DVP, although the patient was already fitted with PVC. PVC may be used according to the criteria of the nursing staff and the test to be performed, as no protocol or guide concerning PVC collection exists. In this hospital, PVC is being changed once every 3 days, and

Strengths and limitations of this study

- Demonstration of equivalence between blood collection methods using direct venous puncture (DVP) and peripheral venous catheter or cannula (PVC) for most routine laboratory tests.
- If the patient is already fitted with PVC or requires it shortly for administration of intravenous medication, the PVC method is preferable in order to reduce punctures.
- Only the most commonly requested laboratory tests for which differences may exist between the results for blood obtained by DVP and PVC had been analysed.
every 2 days if inserted in an emergency room due to infection risk.

Various studies have been conducted without finding differences between the laboratory results obtained with DVP and central venous catheters or arterial catheters. However, comparisons of blood collection using PVC and DVP have been little studied.

This study aimed to analyse linear association, concordance and equivalence between blood collection methods using DVP (control) and PVC.

METHODS
Design and setting
A cross-sectional study of simple crossover design using within-subject measures carried out between October 2011 and May 2012 at the Hospital de Palamós, a reference hospital in the Baix Empordà region. The hospital has 100 beds and assists a large floating population including 10 000 hospitalisations, 57 000 emergencies and 152 892 laboratory requests (12 206 from the inpatient ward) annually.

Study population and sample
Participants studied were aged 18 years or older, admitted to the inpatient ward or emergency services short-stay unit (SSU) and required laboratory studies; all of them were fitted with PVC to administer saline solution, intravenous fluid therapy and/or perfusion or intermittent intravenous medication.

Excluded were participants with PVC collection time exceeding 20 s, difficulty of venoclisis, or who presented with arteriovenous fistula and language difficulties, which made it impossible to comprehend the informed consent, in critical condition or altered state of consciousness with no family to consent.

The minimum sample size was calculated assuming a 5% risk and an 80% potential for detecting a minimal clinically significant difference between DVP and PVC indicated for each laboratory test, standards which were agreed by the research team and all laboratory, internal medicine and emergency medicine medical staff. The SD of the differences between each determination was estimated using a pilot study of 100 patients. The minimum sample size required was 111 participants. Finally, 272 participants were included from the pilot study and those other patients who met the defined selection criteria.

Data collection instruments and procedure
Information was collected via the hospital’s electronic health records and a specific survey for the study, with variables recorded in an Excel database.

One blood sample was extracted for each laboratory test using DVP and another using PVC with an interval under 5 min between them according to a randomised collection sequence. Samples were placed in a tube with individual identification numbers and were simultaneously sent under the same laboratory conditions. Collections were performed during normal hours for these tests by two nurses who were part of the investigational team with a 10 mL Luer syringe and a 21 gauge intravenous needle. Collection using DVP was made from the limb opposite to the one with the PVC. For PVC collection, the intravenous fluid therapy line was first closed for 15 s, as was any medication with the PVC three-way valve, and a syringe was adapted, from which 4 mL of blood was discarded, as recommended in recent studies. Thereafter, the syringe was changed by rotating the valve 1/8 to complete removal. Finally, the venous access was washed with 4 mL of saline solution and intravenous fluid therapy and/or any perfusions were restarted. If clotted blood was detected, the sample was rejected and a new blood collection was performed.

Variables
The dependent variables chosen were the most frequently requested tests for which differences may exist between the laboratory results for blood obtained by DVP and PVC. Each variable was recorded for both collection methods; for biochemistry: amylase (U/L), calcium (mg/dL), total cholesterol (mg/dL), creatinine (mg/dL), creatine kinase (U/L), basal glucose (mg/dL), aspartate aminotransferase (SGOT) (U/L), potassium (mg/L), sodium (mg/L) and urea (mg/dL); for haematology: red blood cells (10^6/μL), haemoglobin (g/dL), leucocytes (10^3/μL), platelets (10^5/μL) and prothrombin ratio (%); and for blood gas: venous blood acidity (pH), venous carbon dioxide partial pressure (po2) (mm Hg) and venous oxygen partial pressure (po2) (mm Hg).

For descriptive purposes, the variables considered and assessed at the time of blood collection were age in years (<65, ≥65), sex, diagnosis, vein insertion of the DVP and PVC (hand, wrist, forearm, inner arm), PVC calibre in gauges (14, 16, 18, 20, 22, 24) and whether saline syringe, intravenous fluid therapy and/or intermitent medication, haemolysis and clotted blood during DVP or PVC collection were used.

Statistical analysis
Univariate descriptive analysis was performed using frequencies for the categorical variables and the mean, SD and quartiles for continuous variables.

Bivariate descriptive analysis included Student t test to analyse differences according to the collection sequence. Pearson’s product-moment correlation coefficient (r) and Lin’s concordance correlation coefficient (rc) were provided for assessing linear association and absolute agreement between the two methods, respectively.

For equivalence analysis, the Bland-Altman agreement interval for 95% (11–14) was calculated for each variable as was the mean difference between methods±1.96 SD of the difference. If the result was within the clinically
accepted interval, defined by the minimum clinically significant difference (as defined by the researcher) comparing DVP and PVC, the methods were considered equivalent.

The CI for estimating proportions was calculated using Wilson’s score method.15 16

The confidence level was deemed to be 95% and the IBM program SPSS Statistics V.21 for Windows17 was used.

Ethical considerations
The study was conducted in accordance with current European and Spanish laws on ethics in research.18

Informed consent was obtained from each study participant and the confidentiality of all data was ensured. The study protocol was approved by the research committee of the Serveis de Salut Integrats Baix Empordà organisation.

RESULTS

In the study, 17 patients were excluded for the following reasons: 5 with PVC collection time exceeding 20 s (29.4%), 7 with difficulty of venousness (41.2%), 1 with arteriovenous fistula (5.9%) and 4 with altered state of consciousness with no family to consent (23.5%).

A total of 272 patients were included, primarily aged 65 or older (80.9%), males (52.6%) and with cardio-respiratory diagnoses (40.1%). The location of the vein for puncture (95.6%) and catheter (45.5%) was usually the inner arm. Mostly 20 calibre intravenous catheters were used (73.3%) without a saline syringe (82.0%) but with intravenous fluid therapy (70.6%), glucosaline solution (34.6%) and intermittent medication (43.4%). Haemolysis occurred in 10 samples (3.7%) on collection using PVC. Clotted blood occurred in two samples (0.7%) and in one sample (0.4%) during DVP and PVC collection, respectively (table 1).

Laboratory findings did not show any differences related to collection sequence between both methods. Positive linear association was observed which was moderate for pO2 (r=0.405) and very high for all other values (r>0.96).

Concordance was low for calcium and blood gas levels (r<0.90), and particularly low for pO2 (r=0.336). It was moderate for potassium, sodium and prothrombin ratio (0.90≤r≤0.95); substantial for cholesterol, creatinine and basal glucose (0.95<r<0.99); and nearly perfect for all other biochemistry levels: amylase, creatine kinase, aspartate aminotransferase and urea (r>0.99).

Collection methods were shown to be equivalent for 10 of the 18 variables studied using the Bland-Altman method: calcium, creatinine, aspartate aminotransferase, potassium, sodium, red blood cells, haemoglobin, leucocytes, platelets and pH. Clinically significant differences were found for the two remaining determinations: pCO2 (21.2%, 95% CI 16.6% to 26.5%) and pO2 (73.1%, 95% CI 67.4% to 78.1%) in more than 9% of cases (table 2).

DISCUSSION

Laboratory tests are necessary for people who are hospitalised or who require urgent care. Routine analyses are requested on admission to the internal medicine department and several times daily in units such as the SSU, intensive care unit (ICU) and coronary unit. Patients often have a PVC inserted, meaning it would be best to

| Variable | n | Per cent | 95% CI |
|----------|---|----------|--------|
| Age (years) | | |
| ≥65 | 220 | 80.9 | (75.8 to 85.1) |
| Sex | | |
| Male | 143 | 52.6 | (46.6 to 58.4) |
| Diagnosis | | |
| Cardiorespiratory | 109 | 40.1 | (34.3 to 46.0) |
| Cerebrovascular | 14 | 5.1 | (3.1 to 8.5) |
| Gastrointestinal | 68 | 25.0 | (20.2 to 30.5) |
| Genitourinary | 28 | 10.3 | (7.2 to 14.5) |
| Osteomuscular | 29 | 10.7 | (7.5 to 14.9) |
| Other | 24 | 8.8 | (6.0 to 12.8) |
| Location of the PVC | | |
| Hand | 2 | 0.7 | (0.2 to 2.6) |
| Wrist | 4 | 1.5 | (0.6 to 3.7) |
| Forearm | 6 | 2.2 | (1.0 to 4.7) |
| Inner arm | 260 | 95.6 | (92.4 to 97.5) |
| PVC calibre (gauges) | | |
| 16 | 2 | 0.7 | (0.2 to 2.6) |
| 18 | 50 | 18.4 | (14.2 to 23.4) |
| 20 | 202 | 74.3 | (68.8 to 79.1) |
| 22 | 18 | 6.6 | (4.2 to 10.2) |
| Saline syringe | | |
| No | 223 | 82.0 | (77.0 to 86.1) |
| Intervenous fluid therapy* | | |
| Saline solution | 85 | 31.3 | (26.0 to 37.0) |
| 5% Glucose solution | 45 | 16.5 | (12.6 to 21.4) |
| Glucosaline solution | 94 | 34.6 | (29.2 to 40.4) |
| Isoplasses | 9 | 3.3 | (1.8 to 6.2) |
| Ringer's | 1 | 0.4 | (0.1 to 2.1) |
| Medication* | | |
| Perfusion | 24 | 8.8 | (6.0 to 12.8) |
| Intermittent | 118 | 43.4 | (37.6 to 49.3) |
| Haemolysis during DVP collection | | |
| Yes | 0 | 0.0 | (0.0 to 1.4) |
| Haemolysis during PVC collection | | |
| Yes | 10 | 3.7 | (2.0 to 6.6) |
| Clotted blood during DVP collection | | |
| Yes | 2 | 0.7 | (0.2 to 2.6) |
| Clotted blood during PVC collection | | |
| Yes | 1 | 0.4 | (0.1 to 2.1) |

*Non-exclusive categories.

DVP, direct venous puncture; PVC, peripheral venous catheter.
Table 2  Linear association, concordance and equivalence between the findings obtained by direct venous puncture and peripheral venous catheter

| Determination | Variable                          | N   | r         | r_c        | CAI                  | n  | 95% CI          | 95% Al | n  | 95% CI          |
|---------------|----------------------------------|-----|-----------|------------|----------------------|----|----------------|--------|----|----------------|
| Biochemistry  | Amylase (U/L)                    | 265 | 0.999     | 0.996      | (−20 to −20)         | 1  | 0.4 (0.1 to −2.1) | −34.09 | 1  | 0.4 (0.1 to −2.1) |
|               | Calcium (mg/dL)                  | 266 | 0.899     | 0.860      | (−1 to −1)           | 2  | 0.8 (0.2 to −2.7)  | −0.90  | 7  | 2.6 (1.3 to −5.3) |
|               | Total cholesterol (mg/dL)        | 269 | 0.984     | 0.983      | (−10 to −10)         | 12 | 4.5 (2.6 to −7.6)  | −13.64 | 6  | 2.2 (1.0 to −4.8) |
|               | Creatinine (mg/dL)               | 271 | 0.982     | 0.982      | (−0.3 to −0.3)       | 4  | 1.5 (0.6 to −3.7)  | −0.25  | 4  | 1.5 (0.6 to −3.7) |
|               | Creatine kinase (U/L)            | 262 | 0.999     | 0.999      | (−20 to −20)         | 13 | 5.0 (2.9 to −8.3)  | −28.76 | 9  | 3.4 (1.8 to −6.4) |
|               | Basal glucose (mg/dL)            | 272 | 0.960     | 0.957      | (−15 to −15)         | 17 | 6.3 (3.9 to −9.8)  | −34.69 | 9  | 3.3 (1.8 to −6.2) |
|               | Aspartate aminotransferase (SGOT) (U/L) | 269 | 0.998     | 0.998      | (−10 to −10)         | 7  | 2.6 (1.3 to −5.3)  | −8.86  | 11 | 4.1 (2.3 to −7.2) |
|               | Potassium (mEq/L)                | 269 | 0.937     | 0.936      | (−0.4 to −0.4)       | 19 | 7.1 (4.6 to −10.8) | −0.45  | 13 | 4.8 (2.8 to −8.1) |
|               | Sodium (mEq/L)                   | 271 | 0.950     | 0.950      | (−4 to −4)           | 4  | 1.5 (0.6 to −3.7)  | −2.63  | 12 | 4.4 (2.6 to −7.6) |
|               | Urea (mg/dL)                     | 269 | 0.997     | 0.997      | (−5 to −5)           | 9  | 3.3 (1.8 to −6.2)  | −6.65  | 7  | 2.6 (1.3 to −5.3) |
| Haematology   | Red blood cells (10^6/μL)        | 268 | 0.988     | 0.986      | (−0.5 to −0.5)       | 3  | 1.1 (0.4 to −3.2)  | −0.22  | 12 | 4.5 (2.6 to −7.7) |
|               | Haemoglobin (g/dL)               | 268 | 0.986     | 0.986      | (−0.6 to −0.6)       | 9  | 3.4 (1.8 to −6.3)  | −0.65  | 8  | 3.0 (1.5 to −5.8) |
|               | Leucocytes (10^3/μL)             | 268 | 0.983     | 0.983      | (−2 to −2)           | 4  | 1.5 (0.6 to −3.8)  | −1.78  | 5  | 1.9 (0.8 to −4.3) |
|               | Platelets (10^3/μL)              | 267 | 0.982     | 0.982      | (−50 to −50)         | 3  | 1.1 (0.4 to −3.3)  | −30.32 | 7  | 2.6 (1.3 to −5.3) |
|               | Prothrombin ratio (%)            | 269 | 0.918     | 0.917      | (−7 to −)            | 22 | 8.2 (5.5 to −12.1) | −16.63 | 5  | 1.9 (0.8 to −4.3) |
| Blood gas     | Venous carbon dioxide potential (pH) | 260 | 0.862     | 0.853      | (−0.1 to −0.1)       | 2  | 0.8 (0.2 to −2.8)  | −0.06  | 11 | 4.2 (2.4 to −7.4) |
|               | Venous carbon dioxide partial pressure (pCO₂) (mm Hg) | 260 | 0.875     | 0.843      | (−5 to −5)           | 55 | 21.2 (16.6 to −26.5) | −6.14  | 10 | 3.8 (2.1 to −6.9) |
|               | Venous oxygen partial pressure (pO₂) (mm Hg) | 260 | 0.405     | 0.336      | (−5 to −5)           | 190 | 73.1 (67.4 to −78.1) | −40.60 | 10 | 3.8 (2.1 to −6.9) |

N, Number of tests with valid findings for direct venous puncture (DVP) and peripheral venous catheter (PVC); n, Number of tests showing differences between DVP and PVC greater than the interval; r, Pearson’s product-moment correlation coefficient; r_c, Lin’s concordance correlation coefficient; CAI, interval defined by the minimal clinically significant difference (according to investigators) between DVP and PVC; 95% AI, interval of agreement of 95% according to the Bland-Altman method: mean difference between methods±1.96 SD of the difference; 95% CI, CI of 95% for proportion according to the Wilson score method.
be able to collect samples by this method if no differences exist in comparison to the DVP method.

Several studies have analysed the concordance between the laboratory values obtained using DVP and PVC, most using PVCs fitted with saline syringes. However, their equivalence has been little studied, sometimes with inadequate methodology, by contrasting means testing or the correlation coefficient, and at other times using a small sample size.

This study showed concordance between the methods used for the variables studied except for calcium and blood gas levels; and equivalence except for pCO2 and pO2. The same results were obtained in a study by Hambleton et al. although concordance for calcium was moderate in that study as analysed using the intra-class correlation coefficient.

However, a study by Berger-Achituv et al. showed that DVP and PVC results were not equivalent for glucose, although that study was performed on children and only DVP and PVC results were not equivalent for glucose, potassium and bicarbonate (not analysed in our study). Potassium level is the laboratory value most vulnerable to sample haemolysis, which was found to be higher when obtained using PVC, although the two methods were found to be equivalent as observed in a study by Kennedy et al.

The equivalency found in our study between the methods for blood collection studied could suggest the use of PVC in patients who are bleeding and/or have infectious diseases, cases for which requests for new haemograms are common. Although our study analysed the prothrombin ratio, others, such as those of Zlotowski et al. and Zengin et al., used prothrombin time, finding equivalency and no difference in mean between the methods.

The non-equivalency of pCO2 and pO2 levels found in the two methods may be due to handling following collection, during transfer of the blood from the Luer syringe to the blood gas syringe or to the time elapsed before samples were analysed. Contact with air causes changes in pO2, and hence the importance of not handling the syringe and of it being filled with the correct amount of blood and excess air removed.

Calcium values obtained with both collection methods had a positive linear association and were equivalent but low concordant. This could be because while in the case of PVC trauma of the puncture was long before the time of blood collection, in DVP this immediate trauma can cause removal of tissue factors and so activate the coagulation process lightly and increase calcium intake.

Our study has some limitations. On the one hand, the laboratory tests chosen were the most frequently requested for which differences may exist between the results for blood obtained by DVP and PVC. So the study results may not be generalisable to all laboratory tests. On the other hand, it would have been beneficial to register the lasting of venesection and not exclude subjects with collection time exceeding 20 s in order to recognise its effect on the studied parameters. Moreover, laboratory tests that were conducted in the study were not standardised.

Blood extraction methods using DVP and PVC can be considered to be equivalent for the variables studied except regarding pCO2 and pO2. With proper syringe handling, they may be used interchangeably.

Elderly population mainly experiences more pain and discomfort with multiple direct venepunctures due to difficult veins, especially if they are performed by professional staff who are non-specialist nurses or non-expert. If the patient is already fitted with PVC or requires it shortly for administration of intravenous medication, the PVC method is preferable in order to reduce punctures, although it is more expensive than the DVP method. Thereby, the patient benefits considerably from lack of pain caused, reduced risk of peripheral neurovascular dysfunction and improved limb surveillance and safety. In other cases, if the patient is not fitted with a cannula and requires a blood collection, the DVP method would be preferable because fitting an unnecessary cannula has drawbacks such as infection risk, phlebitis, cellutitis, haemolysis or clotted blood.

Acknowledgements The authors are most grateful to the administrative and professional staff of SSIBE for recording the information that was essential for the development of the research, to Josep Mª Lisbona for facilitating the data extraction, and to the people who participated in the study.

Contributors NO-A coordinated and designed the study, interpreted the results and drafted the paper. IS-P designed the study, performed and interpreted the statistical analysis and drafted the paper. TB-P and MD-B performed the blood collections. TB-P, MD-B and MP-M acquired, cleaned and interpreted the data and contributed to the write-up. All authors critically revised the paper and are guarantors.

Funding This research received a specific grant from the research fund of the Serveis de Salut Integrats Baix Empordà organisation.

Competing interests None.

Patient consent Obtained.

Ethics approval The study protocol was approved by the research committee of the Serveis de Salut Integrats Baix Empordà organisation.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 3.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/3.0/

REFERENCES

1. Hussey VM, Poulin MV, Pain JA. Effectiveness of lidocaine hydrochloride on venipuncture sites. AORN J 1997;66:472-4, 476, 479–80.
2. Jacobson AF, Winslow EH. Clear benefit for lidocaine preparation for IV sites. Am J Nurs 1997;97:20–1.
3. Marín Fernández B, Ezquerra Rodríguez E. ¿Punción endovenosa directa o catéter endovenoso central? Rev Rol Enf 1990;143–144: 24–6.
4. Monasterio-Huelin y Macía T. ¿Existe un cambio en el resultado analítico a consecuencia de extraer la muestra de sangre de catéter...
central vs sangre venosa periférica por punción directa? Evidencia [Internet]. 2005;2. http://www.index-f.com/evidencia/n6/150articulo.php (accessed 15 Aug 2013).
5. Tineo Drovet T, Baena Pérez M, et al. Comparación de tres métodos de extracción de sangre para gasometrías arteriales de forma indirecta. Nursing 2006;24:62–6.
6. Corbo J, Fu L, Silver M, et al. Comparison of laboratory values obtained by phlebotomy versus saline lock devices. Acad Emerg Med 2007;14:23–7.
7. Arrants J, Willis ME, Stevens B, et al. Reliability of an intravenous intermittent access port (saline lock) for obtaining blood samples for coagulation studies. Am J Crit Care 1999;8:344–8.
8. Evans JD. Straightforward statistics for the behavioral sciences. Pacific Grove, CA: Brooks/Cole Publishing Co., 1996.
9. Lin Li. A concordance correlation coefficient to evaluate reproducibility. Biometrics 1989;45:255–68.
10. Lin Li. A note on the concordance correlation coefficient. Biometrics 2000;56:324–5.
11. McBride GB. A proposal for strength-of-agreement criteria for Lin’s concordance correlation coefficient. Hamilton, NZ: National Institute of Water & Atmospheric Research Ltd, 2005. NIWA Client Report: HAM2005-062. NIWA Project: MOH5201. Report to Ministry of Health.
12. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307–10.
13. Bland JM, Altman DG. Comparing methods of measurements: why plotting difference against standard method is misleading. Lancet 1995;346:1085–7.
14. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res 1999;8:135–60.
15. Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of seven methods. Stat Med 1998;17:857–72.
16. Wilson EB. Probable inference, the law of succession, and statistical inference. J Am Stat Assoc 1927;22:209–12.