then the chemical evidence suggests that a Janovsky complex would result. The evidence adduced by Kroll et al. against Janovsky complex formation is, to my mind, unconvincing.

In particular, one piece of evidence given by Kroll et al. appears to be incorrect. I quote:

> Butler has shown that dicyclohexyl-18-crown-6 ether in benzene reacts with picric acid to form a product that absorbs light similar to compounds in the Jaffé reaction.

I wish I *had* discovered that. However, all I did (*8*) was to use the crown to solubilize inorganic anions in benzene where, because of their "nakedness," they formed Meisenheimer complexes not obtained when polar solvents are used.

A simple way of solving the problem of interference is not available, because carbonyl compounds are ubiquitous. With all its limitations, the Jaffé reaction is the only straightforward non-enzymatic method for assay of creatinine.

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## Organization of a Field Laboratory at an Ultra Marathon

*To the Editor:*

With the increasing participation of many amateur athletes in tests of endurance such as ultra marathons and triathalons, there is more need for medical attention at the end of these races for those who suffer from the physical and metabolic sequelae of exhaustion. For the past two years an on-site field laboratory has been established at the finish of the "Comrades' Marathon," a 90-km event run under extremes of temperature and humidity. Despite numerous refreshment stations and ancillary support, about 2% of the 10 000 runners required treatment in a medical tent at the end of the race, usually via intravenous replacement. While much is known about the biochemical abnormalities during such extreme exercise (*1, 2*), medical personnel have never had the advantages of obtaining immediate biochemical results to help in resuscitation on the spot. Here we report our experience in establishing a field laboratory in the medical tent, to provide rapid biochemical results to aid in immediate medical management.

When (e.g.) 10 000 participants run 90 kilometers over a hilly course at temperatures of up to 28 °C, a field laboratory is extremely useful and occasionally life-saving. Experiences learned about organization and equipment are useful not only for such ultra-endurance events, but also for provision of field-laboratory services in areas of natural disaster or war.

For the 1986 race we offered assays of the following analytes in plasma from venous blood: sodium, potassium, urea, bicarbonate, glucose, osmolality, creatinine, pH, and blood gases, and we determined venous hematocrit. After the first year we decided that many of these tests were unnecessary for immediate management of the patient and that electrolytes, blood gases, calcium, glucose, osmolality, and hematocrit were all that were required for therapy decisions. Table 1 summarizes the instrumentation used. A range of commercial quality-control specimens were assayed regularly (Wellcome Assayed Normal and Abnormal, Gilford Assayed Normal and Abnormal). As a further check, 20% of the runners' specimens were re-assayed the next day in a hospital laboratory. Patients were identified by marshals at the end of the race and were brought to the medical tent for treatment.

In 1986, about 200 patients were admitted to the tent and, of these, 116 had blood specimens tested. In this year, less seriously affected runners were sent to another station 250 m away and did not have blood tests performed. In 1987, about 400 patients were admitted and 240 specimens received.

**Table 1. Equipment Used in a Field Laboratory**

| | |
|---|---|
| **1986** | |
| Corning 614 | (Sodium, potassium) |
| (Ciba-Corning Diagnostic Ltd., Essex, U.K.) | |
| I.L. 1306 | (Blood gases) |
| (Instrumentation Lab. Inc., Lexington, MA 02173) | |
| Beckman BUN 2 | (Urea) |
| (Beckman Instruments, Brea, CA 92621) | |
| Beckman creatinine analyzer | (Creatinine) |
| Roebling osmometer | (Osmolality) |
| (Herman Roebling, 1 Berlin 38, Katteweg 32) | |
| Hematocrit | (PCV) |
| (Hawksley Gelman Instruments, U.K.) | |
| Beckman glucose 2 | (Glucose) |
| Ames glucometer | (Glucose) |
| (Ames—Stoke Poges, Slough SL2 4LY, U.K.) | |
| **1987** | |
| NovaStat Profile 1 analyzer (Nova Biomedical Waltham, MA) | (Sodium, potassium, blood gases, hematocrit, total calcium, ionized calcium) |
| Beckman BUN 2 | (Urea) |
| Roebling osmometer | (Osmolality) |
| Ames glucometer | (Glucose) |

Blood was sampled at the time a cannula was inserted for intravenous fluids. We collected 5 to 10 mL into a heparinized tube and 5 mL into a plain tube with no anticoagulant (for subsequent research). The runners' race number and station number in the tent was attached to the specimen.

In 1986 we measured and removed blood for hematocrit measurement. The specimen was then centrifuged for 5 min and plasma obtained for assay of osmolality, creatinine, glucose, urea, sodium, and potassium in separate analyzers. Results were collected by a clerk, entered on an adhesive form preprinted by a computer, and returned to the pathologist, who reported them to the attending doctor. Results were obtained in 15–20 min. The requirement for centrifugation led to delays in obtaining results that made many of them of no immediate practical use.

In 1987, all results were obtained with a single whole-blood machine.

The remaining blood was centrifuged for plasma, for evaluation of urea and osmolality if requested. Turnaround time was 2–5 min for whole-blood specimens. This shorter time led to prompt diagnosis and management. Eight percent of the patients were hyponatremic, 73% had above-normal creatinine, 40% had above-normal urea, and 32% were hypoglycemic.

In both years, we experienced problems with the heat; the temperature occasionally rose to 30 °C in the shade. Despite the removal of tent-flaps and the use of fans, equipment occasionally overheated, leading to delays. Relocation to another part of the tent would have solved this problem but was not possible because of the location of the power supply.

In 1986, two analyzers were found to be faulty despite thorough testing the previous day. In one case, spares had to be obtained and in another the company's serviceman was present to solve the problem. In 1987 the NovaStat equipment worked perfectly except for problems of temperature.

In certain patients, particularly those who had been confused, unconscious, complaining of severe cramps, or had a history of renal disease, laboratory assessment proved invaluable. Detection of patients with hyponatremia was also important, to avoid administering large quantities of hypotonic fluid to them.

We have demonstrated that it is possible to organize a field laboratory that gives rapid, reliable, and clinically useful information in a medical tent catering to the resuscitation of amateur athletes who are undergoing physical stresses encountered in high heat and humidity in an ultramarathon.

In summary, we offer the following recommendations for operating a laboratory under such conditions:

- Locate laboratory in coolest possible place with good ventilation.
- Avoid centrifugation if at all possible (use whole-blood machinery).
- Have tested back-up equipment available as well as spares.
- Report rapid results on a few important analytes (sodium, hematocrit) which is more valuable than slower, more detailed results.
- Link up results to the race computer if possible.


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## Clinical Significance of Subnormal Values for Thyrotropin

*To the Editor:*

Recently, several immunometric assays that purport to distinguish between hyperthyroid, hypothyroid, and euthyroid patients have been described (*1, 2*). I evaluated the Amerlite "highly-sensitive" thyrotropin (TSH) assay in a routine laboratory setting and found several discrepancies.

Currently, free thyroxin (FT4), total triiodothyronine (T3; Amerlex M, Amersham), and TSH by an immunoradiometric assay (Corning) are measured on all requests for thyroid function. The routine TSH assay does not distinguish between subnormal and normal values of TSH.

For the Amerlite TSH assay, the calculated between-assay CV over 15 different assays was 6.3% at 0.62, 6.1% at 6.4, and 6.9% at 24.2 milli-int. units/L. The sensitivity of the assay, calculated as 2.7 times the SD for 12 singleton zero-standard determinations, was <0.05 milli-int. unit/L. The assay was considered to be easy to use, robust, with a satisfactory reproducibility and sensitivity.

The laboratory test strategy was used to classify 251 unselected patients from the routine thyroid workload into: euthyroid (n = 136) with FT4, T3, and TSH within the normal range; hypothyroid (n = 6) with low FT4 and increased TSH; hyperthyroid (n = 4) with increased FT4 and T3, and normal TSH; subclinical hypothyroid (n = 11), with normal FT4 and increased TSH; sick euthyroid (n = 5), with low FT4 and normal TSH; and hyper/hypothyroid under treatment (n = 73). Patients being treated for thyroid disease were identified by their case notes. Half of the patients in the study were older than 50 years.

The Amerlite TSH assay correctly classified 136 cases of euthyroidism, six cases of untreated hypothyroidism, four cases of untreated hyperthyroidism, and 11 patients with subclinical hypothyroidism. Five patients considered as sick euthyroid were classified as euthyroid by the Amerlite assay, with normal values for TSH. For two patients on amiodarone therapy and with increased FT4, the Amerlite TSH values were normal and <0.05 milli-

**Table 1. Patients with Discordant TSH Values**

| Patient | $FT_4$, pmol/L | $T_3$, nmol/L | TSH, milli-int. units/L: Corning | TSH, milli-int. units/L: Amerlite | Age, y | Clinical information |
|---|---|---|---|---|---|---|
| *a: Patients with euthyroid multinodular goiter* | | | | | | |
| 1 | 14.3 | 1.3 | 0.6 | <0.05[a] | 85 | Nodular goiter |
| 2 | 10.3 | 2.2 | 1.4 | <0.05 | 46 | Nodular goiter |
| 3 | 14.4 | 1.6 | 0.7 | <0.05 | 66 | Multinodular goiter |
| *b: Patients on drug therapy* | | | | | | |
| 4 | 21.7 | 2.2 | 1.3 | <0.05 | 53 | On prednisolone |
| *c: Elderly patients treated for nonthyroidal illness* | | | | | | |
| 5 | 21.0 | 1.1 | 0.6 | 0.13 | 76 | Anorexia |
| 6 | 21.2 | 1.6 | 1.6 | 0.09 | 72 | Myocardial infarct |
| 7 | 20.5 | 2.5 | 0.3 | <0.05 | 73 | Lung cancer |
| 8 | 17.9 | 1.6 | 0.8 | 0.11 | 78 | Confused |
| 9 | 19.4 | 1.6 | 0.8 | <0.05 | 75 | Osteoporosis, osteoarthritis |
| 10 | 18.2 | 0.7 | 0.8 | 0.09 | 80 | Diabetes |
| 11 | 15.2 | 1.4 | 1.4 | 0.14 | 84 | Cervical spondylitis |
| 12 | 18.4 | 2.0 | 0.7 | 0.12 | 82 | General malaise |
| 13 | 19.7 | 1.5 | 1.6 | 0.08 | 79 | COAD |
| 14 | 15.0 | 1.0 | 0.4 | <0.05 | 76 | Urinary tract infection |
| *Reference ranges* | 10.4–25.7 | 0.8–2.5 | <6.0 | 0.15–3.2 | | |

[a] Detection limit: <0.05 milli-int. unit/L.