Therapeutic Devices and Systems

ON LINE DIAGNOSIS OF PROBLEMS IN DRIP INFUSION SYSTEM BY IMPEDANCE AND FLOW MEASUREMENT

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ABSTRACT
During intravenous infusion even though the limb is immobilized, often needle punctures the vein and fluid accumulates subcutaneously. Also the infusion rate is affected by total or partial blockage of the needle. None of the existing system give early warning to the attendant so that timely corrective measures are taken. A new technique based upon electrical impedance and flow measurement is suggested to solve the problem. The method utilizes on line data obtained regarding the static, slow and fast changes in the limb impedance and of the rate of infusion. Using the data and the relations an algorithm is developed and implemented on a uP computer. Processor triggers an alarm that stops infusion when the trouble in the system is detected.

INTRODUCTION
Intravenous infusion is a part of therapeutics in many disease conditions. Some common problems encountered are the needle slipping out of the vein and the infusate fluid accumulating in the subdermal tissue; the needle getting blocked; and the flow rate becoming too low or too high. These problems become more frequent and severe if the infusion needs to be continued for long durations. Conventionally the vein is cannulated and fluid is allowed to flow by gravity feed. This requires immobilization of the limb and the needle to be held in position by adhesive tape. The attendant keeps a watch on the drop rate. In case of change in the infusion rate or if marginal swelling is observed in the vicinity of the insertion point steps are taken to avert further complications. Therefore medical personnel have to be on constant alert when critical patients are being given infusion using conventional drips. Situation becomes unmanageable if patient number is large. Controlled rate infusion pumps were introduced to overcome the variability in the infusion rate encountered in the drip system. Even in these the problem of slipping out of the needle and partial blockage of the needle remain.

Although drip infusion is widely used attempts to improve the system are remarkably few. In one advancement there is a drop rate counter and deviation from the preset drop rate activates an audible alarm thus calling for remedial action. Some other models also have an inbuilt alarm which is trigged when the fluid in the infusate reservoir is exhausted [1,2]. These measures are not adequate. For effective management it is necessary to differentiate the various infusion problems since management methods differ.

The system should be able to analyse and display factors responsible for parametrical deviation in the actual venous inflow rate from the desired value. It is to be noted that the venous inflow rate is not necessarily equal to the outflow rate from the infusion system. A novel approach to deal with these issues is suggested.

METHOD
The proposed method employs the measurement of electrical impedance in the tetrapolar mode and the flow rate of the infusate. The quantities which are sequentially being estimated are:

a. contact impedance \( Z_c \) between the body and the current electrode system;
b. limb impedance \( Z \) in the vicinity of the insertion point of the needle;
c. the impedance \( Z_n \) between the needle and a potential electrode;
d. drop rate \( R \)

Fig (1) shows the schematic of the complete instrumentation system. Two band electrodes 1-1' the current electrodes are placed around the arm to introduce constant current into the body [3] and electrodes 2-2' are used to pickup the voltage equivalent to the electrical impedance \( Z \) of the region close to the insertion point of the needle. The impedance \( Z_n \) between the needle inside the vein and the electrode 2 is also measured and helps toward identification of needle slippage out of the vein. The contact impedance \( Z_c \) is estimated by measuring the current flowing through the resistance in series with the electrode 1' using a monitor having much lower time constant than the current regulator within the plethysmograph. The infusion rate \( R \) is quantified by the optical transducer placed on the air trap of the conventional drip. Discrete values of these parameters \( Z_c, Z, Z_n, R \) and their first differentials

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DZ/dt, dZ/dt, dZn/dt and dR/dt are then multiplexed and sequentially sampled by the 8085 uP computer.

Algorithm for the measuring scheme is fused in the EPROM of the uP. When the infusion system is connected to the patient the initial values of the impedances and the flow rate are stored in the computer memory. Thereafter the incoming patient data is continuously compared with the stored normal data. If any change in the stored parameter is observed, then the inbuilt algorithm rechecks the observation. After validation the system ascertains the possible causes of the problem and activates an audible alarm accordingly. At the same time a visual display flashes the cause of system failure.

At present the system is able to differentiate the problems associated with needle blockage or slippage, fluid leakage or change in infusion rate and the movement artifacts. Details of associated problems are:
1. Needle blocked but in the vein
2. Needle blocked but outside the vein
3. Needle blocked and totally outside the body
4. Partial blockage of the needle
5. Needle out and fluid leaking outside the body
6. Fluid exhausted
7. Needle punctured through the vein and blood accumulating in subcutaneous tissue
8. Needle punctured through the vein and blood accumulating subcutaneous tissue
9. Artifacts due to body movement or loose contact at to electrodes.
10. Artifacts due to the electrodes.

Significant advantages of the technique over the conventional drip infusion systems are:
1. Once the drip is started and the electrodes are placed in position no attention on the part of the medical personnel is required unless the alarm is activated. No time is wasted in assessing the extent of problem. No modification is required in conventional drip sets commercially available. No sterilization or special preparation is necessary for placing the electrodes on the patient. The whole measurement is easy to perform with minimum discomfort to the patient.

REFERENCES

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