

Calculator assisted determination of dilutions for continuous infusion ICU medications

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A program has been developed for simplification of initial dilution calculations for several rapidly metabolized, vasoactive drugs that must be administered by continuous infusion. Included in the program is the capability for serial recalculation of drug dosage or iv flow rate as well as a checking routine to reduce errors. This program was developed primarily for the pediatric age group, where dilution of drugs into a small volume of diluent, accurate dosage calculations, and low iv flow rates are frequently necessary.

Critical care has recently been complicated by the increasing use of drugs that must be administered by continuous infusion because of their rapid metabolism and vasoactive character. The optimal dosage of these medications is usually determined by the patient's physiological response, thereby, often making multiple calculations necessary. The safe use of such drugs requires meticulous monitoring and accurately calibrated infusion pumps. In using these drugs, a potential for large errors in computation may result when these calculations are carried out by hand. Some ICUs have developed charts for administration of these drugs, which have been very helpful, but have the disadvantage that a constant dilution must be used. In pediatrics, this frequently makes the volume administered to the patient inordinately large, thus, potentially compromising the patient with fluid overload. The availability of the programmable bedside calculator, which can be readily operated by personnel without a computer background, has recently simplified the task of tedious mathematical calculations.

A program for the administration of several of these medications has been developed for the Hewlett-Packard 41C (HP-41C) calculator with printer. Use of this calculator with its alphanumeric capabilities can easily be mastered by personnel who do not have a computer background. The program we have developed is presently being used to simplify calculations for constant infusion of dopamine, nitroprusside, epinephrine, isoproterenol, prostaglandin E₁, and lidocaine.

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METHODS

The program itself is seen in Figure 1. The execution of the program is seen in Figure 2. After passing the program cards through the card reader of the HP-41C, the program designated *ICM* is entered into the constant memory of the calculator. The program can then be recalled by use of the letters *ICM* or the entire procedure simplified by utilizing the *USER* mode of the HP-41C and assigning the program to be recalled by the use of a single key.

On successful initiation of the program, the user is prompted by "DRUG ID." At this point, the user then enters the first two letters of the generic drug name. For example: *EP* for epinephrine. If the drug desired is not in file, "NONEXISTENT" will appear and the program must be reinitiated. If the desired drug is on file, the drug name and dosage range will be printed and the user prompted for the patient information, which includes the desired infusion dose in $\mu\text{g}/\text{kg}\cdot\text{min}$, the patient's weight in kg, the iv flow rate in ml/h, the medication concentration in mg/ml or $\mu\text{g}/\text{ml}$ in the ampul, and the total number of ml of the desired infusion to be made. These numeric values are entered with the *R/S* key as prompted. The program then calculates the appropriate number of ml of the drug from the ampul that is to be combined with diluent to obtain the previously determined final volume of infusion.

The user is then prompted by *R/D* or *D/R* indicating that serial recalculations will be performed depending on the input variable. The operator selects which input variable is desired by depressing the alpha keys; *RD* for obtaining iv flow rate from a change in dose or *DR* to obtain the dose rate from a change in iv rate. After the selection is made, the user is prompted to enter the appropriate numeric values with the *R/S* key. For example, *DR* would prompt for the intravenous flow rate in ml/h and then calculate the dosage in $\mu\text{g}/\text{kg}\cdot\text{min}$ that would be delivered at that rate. Should the user not wish to perform serial recalculations but wish to calculate another drug, the program may be reinitiated by depressing *NO*.

If the dose entered or the serial recalculation results in an actual dosage that would fall outside of the established dosage range, the user is alerted by an audible signal and queried. Should the operator then choose to correct the calculation, the keys *NO* are depressed and the correct

| | | | | |
|--------------------|--------------------|--------------------|----------------------|----------------------|
| 01*LBL "ICM" | 65 "DOSE RANGE=" | 120*LBL 04 | 170*LBL 31 | 243*LBL 42 |
| 02*LBL 00 | 66 ACA | 121 "CN MED UG/CC" | 179 RCL 12 | 244 SF 10 |
| 03 CF 09 | 67 PRBUF | 122 PROMPT | 180 RCL 13 | 245 ADV |
| 04 CF 10 | 68 FIX 1 | 123 STO 03 | 181 XYY? | 246 "RATE FROM DOSE" |
| 05 CF 11 | 69 .05 | 124 "CN MED " | 182 GTO 32 | 247 PRA |
| 06 ADV | 70 RCL 14 | 125 XEQ 24 | 183 RCL 13 | 248 ADV |
| 07 CF 05 | 71 X<Y? | 126 "/CC=" | 184 RCL 14 | 249 "DOSE UG/KG/M" |
| 08 AOH | 72 FIX 3 | 127 ACA | 185 XYY? | 250 PROMPT |
| 09 "DRUG ID?" | 73 ACX | 128 RCL 03 | 186 GTO 32 | 251 STO 10 |
| 10 PROMPT | 74 "-- | 129 ACX | 187 GTO 33 | 252 STO 13 |
| 11 ASTO 08 | 75 ACA | 130 PRBUF | 188*LBL 32 | 253 XEQ 22 |
| 12 CLA | 76 FIX 1 | 131 1000 | 189 "NO" | 254 .05 |
| 13 AOFF | 77 RCL 12 | 132 / | 190 ASTO Y | 255 RCL 10 |
| 14 GTO IND 08 | 78 ACX | 133 STO 03 | 191 CLA | 256 X<Y? |
| 15*LBL "DO" | 79 CLA | 134*LBL 05 | 192 BEEP | 257 FIX 3 |
| 16 "DOPAMINE" | 80 " " | 135 "CC SOLN" | 193 AOH | 258 ACX |
| 17 5 | 81 XEQ 24 | 136 PROMPT | 194 "Y OR NO ?" | 259 PRBUF |
| 18 STO 14 | 82 "/KG/M" | 137 STO 04 | 195 PROMPT | 260 FIX 2 |
| 19 20 | 83 ACA | 138 XEQ 23 | 196 ASTO X | 261 GTO 31 |
| 20 STO 12 | 84 PRBUF | 139*LBL 11 | 197 CLA | 262*LBL 36 |
| 21 GTO 21 | 85 ADV | 140 RCL 00 | 198 AOFF | 263 RCL 10 |
| 22*LBL "EP" | 86*LBL 01 | 141 RCL 04 | 199 X=Y? | 264 RCL 05 |
| 23 "EPINEPHRINE" | 87 SF 09 | 142 .06 | 200 GTO 34 | 265 * |
| 24 .1 | 88 FIX 2 | 143 * | 201*LBL 33 | 266 RCL 06 |
| 25 STO 14 | 89 "DOSE UG/KG/M" | 144 * | 202 FS?C 09 | 267 / |
| 26 1 | 90 PROMPT | 145 RCL 03 | 203 GTO 02 | 268 STO 09 |
| 27 STO 12 | 91 STO 01 | 146 / | 204 FS?C 10 | 269 "IV RATE CC/H" |
| 28 GTO 21 | 92 STO 13 | 147 STO 05 | 205 GTO 36 | 270 XEQ 23 |
| 29*LBL "IS" | 93 XEQ 22 | 148 RCL 01 | 206 FS?C 11 | 271 ADV |
| 30 .1 | 94 .05 | 149 RCL 02 | 207 GTO 35 | 272 GTO 37 |
| 31 STO 14 | 95 RCL 01 | 150 / | 208*LBL 34 | 273*LBL 22 |
| 32 1 | 96 X<Y? | 151 * | 209 FS?C 09 | 274 "DOSE " |
| 33 STO 12 | 97 FIX 3 | 152 STO 06 | 210 GTO 01 | 275 XEQ 24 |
| 34 "ISOPROTERENOL" | 98 ACX | 153 FIX 2 | 211 FS?C 10 | 276 "/KG/M=" |
| 35 GTO 21 | 99 PRBUF | 154 .05 | 212 GTO 42 | 277 ACA |
| 36*LBL "LI" | 100 GTO 31 | 155 RCL 06 | 213*LBL 41 | 278 RTN |
| 37 20 | 101*LBL 02 | 156 X<Y? | 214 SF 11 | 279*LBL 23 |
| 38 STO 14 | 102 FIX 1 | 157 FIX 3 | 215 ADV | 280 ACA |
| 39 50 | 103 "IV RATE CC/H" | 158 ADV | 216 "DOSE FROM RATE" | 281 "-- |
| 40 STO 12 | 104 PROMPT | 159 ACX | 217 PRA | 282 ACA |
| 41 "LIDOCAINE" | 105 STO 02 | 160 "CC " | 218 ADV | 283 ACX |
| 42 GTO 21 | 106 XEQ 23 | 161 ACA | 219 "IV RATE CC/H" | 284 PRBUF |
| 43*LBL "NI" | 107*LBL 03 | 162 ASHF | 220 PROMPT | 285 RTN |
| 44 .5 | 108 FIX 1 | 163 ARCL 10 | 221 STO 07 | 286*LBL 24 |
| 45 STO 14 | 109 "WT IN KG" | 164 ACA | 222 XEQ 23 | 287 ACA |
| 46 12 | 110 PROMPT | 165 ASHF | 223 RCL 05 | 288 12 |
| 47 STO 12 | 111 STO 00 | 166 ARCL 11 | 224 1/X | 289 ACCHR |
| 48 "NITROPRUSSIDE" | 112 XEQ 23 | 167 ACA | 225 RCL 07 | 290 103 |
| 49 GTO 21 | 113 FS? 05 | 168 ASHF | 226 RCL 06 | 291 ACCHR |
| 50*LBL "PR" | 114 GTO 04 | 169 ARCL 15 | 227 * | 292 RTN |
| 51 SF 05 | 115 "CN MED MG/CC" | 170 ACA | 228 * | 293*LBL 25 |
| 52 .025 | 116 PROMPT | 171 PRBUF | 229 STO 08 | 294 ADV |
| 53 STO 14 | 117 STO 03 | 172 "FROM AMPULE " | 230 STO 13 | 295 ADV |
| 54 .1 | 118 XEQ 23 | 173 ACA | 231 XEQ 22 | 296 ADV |
| 55 STO 12 | 119 GTO 05 | 174 "INTO SOLN" | 232 .05 | 297 ADV |
| 56 "PROSTAGLANDIN" | | 175 ACA | 233 RCL 08 | |
| 57*LBL 21 | | 176 PRBUF | 234 X<Y? | |
| 58 ACA | | 177 GTO 25 | 235 FIX 3 | |
| 59 ASTO 10 | | | 236 ACX | |
| 60 ASHF | | | 237 PRBUF | |
| 61 ASTO 11 | | | 238 FIX 2 | |
| 62 ASHF | | | 239 GTO 31 | |
| 63 ASTO 15 | | | 240*LBL 35 | |
| 64 PRBUF | | | 241 ADV | |
| | | | 242 GTO 37 | |
| | | | | 298*LBL 37 |
| | | | | 299 FIX 2 |
| | | | | 300 "RD" |
| | | | | 301 ASTO 17 |
| | | | | 302 "DR" |
| | | | | 303 ASTO 18 |
| | | | | 304 AOH |
| | | | | 305 "R/D, D/R, NO?" |
| | | | | 306 PROMPT |
| | | | | 307 ASTO X |
| | | | | 308 CLA |
| | | | | 309 AOFF |
| | | | | 310 ARCL 17 |
| | | | | 311 ASTO Y |
| | | | | 312 CLA |
| | | | | 313 X=Y? |
| | | | | 314 GTO 42 |
| | | | | 315 ARCL 18 |
| | | | | 316 ASTO Y |
| | | | | 317 CLA |
| | | | | 318 X=Y? |
| | | | | 319 GTO 41 |
| | | | | 320 GTO 00 |
| | | | | 321 END |

Fig. 1. Program.

DOPAMINE
DOSE RANGE=
5.0- 20.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 10.00
IV RATE CC/H= 3.0
WT IN KG= 5.0
CN MED MG/CC= 40.0
CC SOLN= 30.0

0.75 CC DOPAMINE
FROM AMPULE INTO SOLN

LIDOCAINE
DOSE RANGE=
20.0- 50.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 20.00
IV RATE CC/H= 5.0
WT IN KG= 15.0
CN MED MG/CC= 10.0
CC SOLN= 50.0

10.00 CC LIDOCAINE
FROM AMPULE INTO SOLN

information re-entered. If the user agrees with the calculated dosage outside of the variables and desires to proceed with the program, Y (yes) is entered.

SUMMARY

This programmed computation of drug dosages is intended to simplify patient care and reduce the possibility of errors in calculation of continuous drug infusion. The flexibility of solution preparation and serial recalculation of drug dose and iv flow rate which is crucial in pediatric critical care is augmented by this program. In addition, the relatively inexpensive nature of the programmable calculator enables it to be used in both large and small critical care units.

RATE FROM DOSE

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 17.00
IV RATE CC/H= 5.10

NITROPRUSSIDE
DOSE RANGE=
0.5- 12.0 $\mu\text{g}/\text{KG}/\text{M}$

EPINEPHRINE
DOSE RANGE=
0.1- 1.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 1.00
IV RATE CC/H= 5.0
WT IN KG= 5.0
CN MED MG/CC= 50.0
CC SOLN= 25.0

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 5.0
WT IN KG= 15.0
CN MED MG/CC= 1.0
CC SOLN= 50.0

0.030 CC NITROPRUSSIDE
FROM AMPULE INTO SOLN

0.90 CC EPINEPHRINE
FROM AMPULE INTO SOLN

PROSTAGLANDIN
DOSE RANGE=
0.025- 0.1 $\mu\text{g}/\text{KG}/\text{M}$

DOSE FROM RATE

IV RATE CC/H= 6.70
DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.13

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 5.0
WT IN KG= 5.0
CN MED $\mu\text{g}/\text{CC}$ = 50.0
CC SOLN= 25.0

ISOPROTERENOL
DOSE RANGE=
0.1- 1.0 $\mu\text{g}/\text{KG}/\text{M}$

3.00 CC PROSTAGLANDIN
FROM AMPULE INTO SOLN

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 10.0
WT IN KG= 10.0
CN MED MG/CC= 0.2
CC SOLN= 50.0

1.50 CC ISOPROTERENOL
FROM AMPULE INTO SOLN

FIG. 2. Program execution.