
Applications of a Laptop Microcomputer During Cardiopulmonary Bypass

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Abstract

A "user friendly" microcomputer-generated data management system designed for on-site documentation and immediate analysis of patient parameters during cardiopulmonary bypass is presented. The program is a macro-driven template for use with Lotus 1-2-3 (ver. 2.0) on IBM PC-XT or compatible such as the Zenith Z-183 Laptop computer used in this report. Automatic calculation of data requiring minimal input includes kilos, centimeters, body surface area, blood flow, fluid balance, heparin, protamine and mannitol dose and systemic vascular resistance. Also included is autocomputation of documented minimum, maximum and average pressure, blood flow, oxygen flow/percent, temperature, activated clotting time and SVR. Basic file functions are easily performed as saving, retrieving, deleting and report generation. Database management capabilities include sorting by contents of fields, searching for specific records and graphing of selected parameters. The use of a computer-generated perfusion record has become a valuable tool in the tracking and evaluation of important patient parameters during cardiopulmonary bypass.

Introduction

A microcomputer-based charting system has been in use for documentation and evaluation of patient parameters during bypass. The program is a template to be used with Lotus 1-2-3^a and is used by the perfusionist for charting during cardiopulmonary bypass

on a laptop microcomputer. Data collected are printed out and included as part of the patient's permanent record. All data collected are backed up weekly to tape and stored for later retrieval and analysis.

Materials and Methods

The laptop computer used in this study is the Zenith Z-183^b with a 10-megabyte hard disk MS-DOS 3.2 640K RAM (Figure 1). The computer runs at 8 MHZ and has a 8086 processor. We found the back-lit screen to be clear and easy to read. In addition the unit is sturdy in design with a well-designed keyboard (Figure 2). A laptop computer was selected because of its portability, a plus on long-term assist cases. It is compact requiring little space and operates on AC or DC power preventing data loss during power outages. All patients charts are saved to the hard disk.

The printer used is an Epson^c printer and all charts are printed in triplicate after each case for various hospital needs.

All patient data collected on the department's two laptop computers are transferred weekly to hard disk on a desktop IBM PC-XT^d and immediately backed up using a Irwin^e tape back-up system for later retrieval and analysis of the data.

The program developed is a macro-driven template for use with Lotus 1-2-3 (ver. 2.0). Both Lotus and the program titled "AUTO123" are copied to hard disk for ease of use. This prevents changing of floppy disks during use and loading of the program. "AUTO123" is a automatically loading spreadsheet.

All normally recorded patient parameters during cardiopulmonary bypass are recorded as well as

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c Epson American International, Torrance, CA 90505

d International Business Machines Corporation, Boca Raton, FL 33432

e International Instrumentation Inc., West Lake Village, CA 91362



Figure 1: Zenith Z-183 with a 10-megabyte hard disk MS-DOS 3.2 640K RAM.



Figure 2: The Zenith Z-183 keyboard is uncrowded for larger hands and has a solid feel. The function keys are positioned at the top of the keyboard.

important preoperative information (Figure 3^{abc}). Automatic calculation of selected parameters is accomplished through formulas resident in the program.

Actual data entry is facilitated through the use of macros. A macro is a two-keystroke combination invoking a user-defined program. The use of macros reduces data entry time and increases consistency and accuracy in data entry. All events usually recorded by the perfusionist during a case are written in macro form reducing a many-keystroke combination to a series of two. Figure 4 shows the input and its associated macro output.

A graphic representation of temperature trends (Figure 5) and anticoagulation management (Figure 6) during the case is instantly available through a macro driven menu.

Standard file functions such as saving, retrieving, deleting and printing are easily performed through a macro driven menu.

Results

Through use of this program, essential information is collected in a uniform and organized fashion creating a database of information. Evaluation of data collected is done rapidly and easily through macros written specifically for database management. Records can be queried for the latest trends and relational aspects without hours of searching through charts or additional programming.

Searches through the database can be as simple as finding all coronary bypass patients or as difficult as finding all of the female patients between the ages of 45 and 55, with a body surface area between 1.52 and 1.70, having coronary bypass surgery, with O positive blood, receiving one or more units of blood on bypass, on an urgent status, using a Bentley CM50, by perfusionist Smith and surgeon Jones.

Graphic representation of database searches is macro driven and takes the form of a pie chart, bar graph, line graph or an XY graph (Figure 7^{abcd}).

Statistical functions such as standard deviation, variance, minimum, maximum, average, mean, and standard deviation are available when a database query is performed.

Billing and short operative reports can be generated eliminating the need to switch to a new program through the use of macros.

Discussion

Implementation of computer charting was done in four stages lasting four weeks.

PATIENT NAME: SMITH, JOHN
DATE: 03/01/88
AGE: 72
HT: 181.6
WT: 152.4
BSA: 1.85
ALLERGIES: NKA

BLOOD GAS AND ELECTROLYTE ANALYSIS

Table with columns: TIME, PH, PCO2, PO2, BE, TCO2, TBA, TCV, TCT, NA, K, GLU, ACT, HCON. Contains multiple rows of blood gas and electrolyte data points over time.

Signature: _____
T/N: _____

TOTAL #
BLOOD GCS: [Data]
PROCEDURE: [Data]
CNO: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000

CELL SAVER LOT # CC'S SAVED VALVE POSITION/SIZE SERIAL # OTHER SERIAL # LOT #
243 18407 900.00 HPA H481550 FRANKLIN

ANESTHESIA PERfusionIST PERfusionIST MANNITOL HEPARIN BYPASS CLAMP PUMP VOLUME GAIN (ML) --
B1 B2 201 DOSE (CC) DOSE (MG) TIME (MIN) TIME (MIN) L.R. MANCOX HEP. & PROT. MANNITOL
HARRIS HARRIS 222 292 229 85 2200 50 150 222

ALBUMIN CPBS BLOOD TOTAL (ML) REMAIN IN PUMP SAMPLES TOTAL (ML) PUMP GAIN FLUIDS BLOOD TOTAL GAIN (ML) SPONGE ETC. URINE
200 700 250 3772 2000 200 2200 1572 1100 450 3122 1000 750

SURGICAL RISK FAILURE
TOTAL LOSS #FINAL TOTAL CLASS TOTAL CLASS COMMENTS
1750 1372 B 15 3 PRE URINE=500, DURING URINE=200CC, PRE CB=4.9 D.W., E.F=45L

GAS STAT ON ARTERIAL LINE.
DIY STAT ON VENOUS LINE.
AIR AND LEVEL DETECTOR
USED IN AUTO-OFF MODE.

Table with columns: TIME, E, I, A, R, I, C, V, P, A, P, HR, FLOW, I, O, 2, I, E, I, B, S, V, R. Contains detailed perfusion parameters and drug administration records over time.

Figure 3. Patient Chart.

- a. Page 1 contains the parameters most often queried in the database. Formulas resident on page one for automatic calculation include: conversion of inches and pounds to centimeters and kilograms, calculation of B.S.A., blood flows, heparin and mannitol dose, and fluid balance.
- b. Page 2 contains event listings, a blood record and a drug chart. Pressure, flow, and temperature values are also recorded. The minimum, maximum and average of each parameter recorded are recalculated each time a new entry is made.
- c. Page three contains all blood gas and electrolyte values.

MACRO INPUT AND OUTPUT

PRESS [ALT] KEY AND LETTER CODE

CODE	OUTPUT	CODE	OUTPUT
J	TIME BG/ACT/HEPCON	A	TIME ARIMINE (MG)
F	TIME OFF BYPASS	C	TIME CACL (MG)
O	TIME ON BYPASS	D	TIME CDPG (CC)
X	TIME X-CLAMP ON	H	TIME HEPARIN (MG)
Z	TIME X-CLAMP OFF	L	TIME LIDOCAINE (MG)
E	TIME ELEC. DEFIB.	Y	TIME NEOSYN (MG)
S	TIME SPONT. DEFIB.	G	TIME NTG (MG)
B	TIME FIBRILLATION	K	TIME KCL (M/EQ)
R	TIME REWARM	P	TIME PROTAMINE (MG)
M	FILE PRINT MENU	N	TIME NAHCO3 (M/EQ)
W	GRAPH MENU	T	TIME THORIZINE (MG)
I	SELECT OPTION	Q	TIME ONLY

Figure 4: Keyboard input and associated macro output.

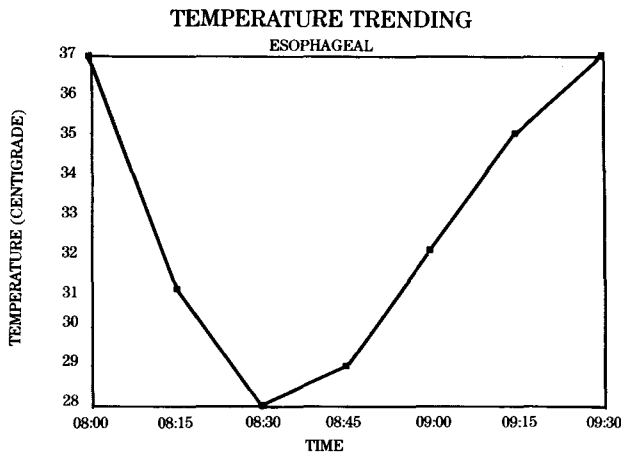


Figure 5: Representation of a macro-driven temperature trend graph instantly available during bypass.

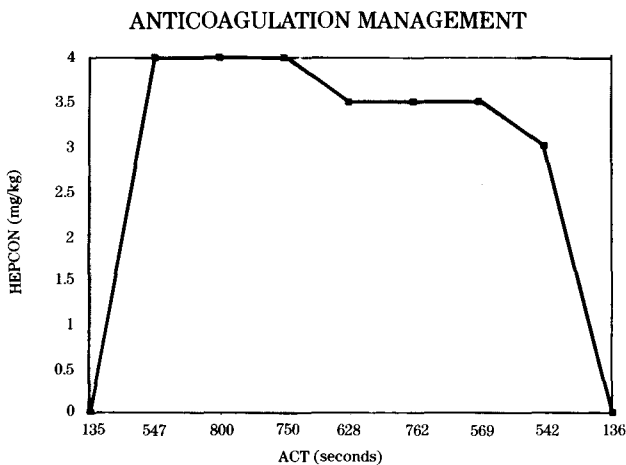


Figure 6: Representation of a macro-driven anticoagulation management graph instantly available during bypass.

The first stage, lasting two weeks, required two perfusionists. The primary perfusionist was solely responsible for perfusion duties while the secondary perfusionist was responsible for computer charting.

The second stage, lasting one week, also required two perfusionists. The primary perfusionist was responsible for perfusion duties and computer charting while the secondary perfusionist, stationed by the heart-lung machine, was on hand to assist as needed.

The third stage, lasting one week, required the primary perfusionist and a circulating secondary perfusionist. The primary perfusionist was responsible for both perfusion and charting duties while a circulating secondary perfusionist resumed normal duties. At the end of the third stage the perfusion staff had become proficient in data entry and report generation.

The fourth stage was complete conversion to computer charting for all future cases.

Initial development and individual customizing of the program is comparatively an uncomplicated procedure through the many support books and additional software available to the serious programmer.¹⁻³

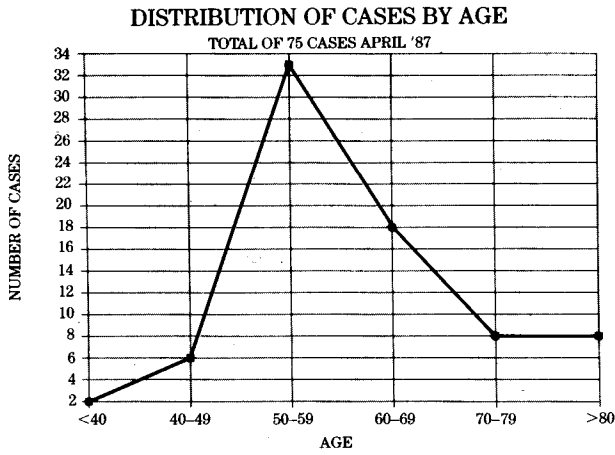
Through adequate and safe training for the perfusion staff, this addition to the operating room has been a beneficial one for the staff, hospital and patients alike.

Acknowledgment

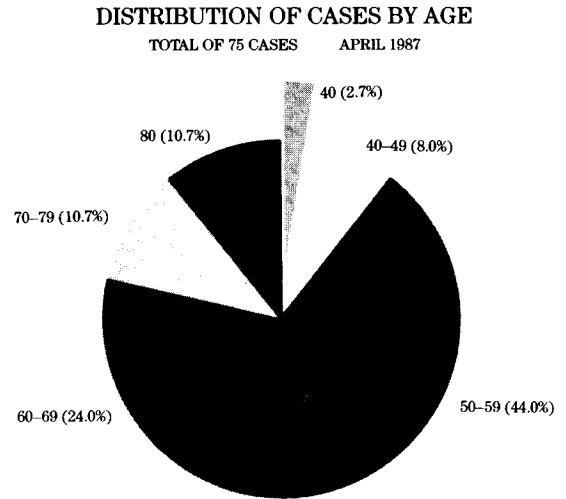
Special thanks to John E. Hutchinson III, M.D. for his generous support of this project.

References

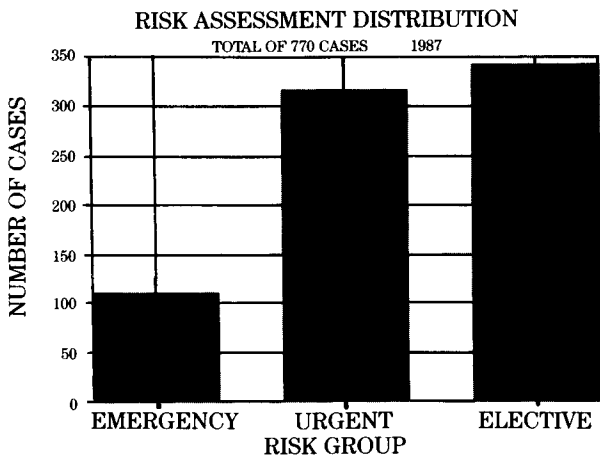
1. LeBlond, GT and Cobb, DG: *Using 1-2-3*, 2nd edition. Indianapolis, Indiana, Que Corporation, 1986.
2. Ewing, DP: *1-2-3 Macro Library*, 2nd edition. Indianapolis, Indiana: Que Corporation, 1986.
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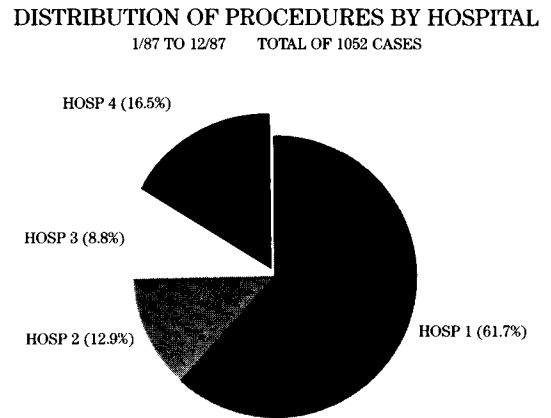
A.



B.



C.



D.

Figure 7: Database graphic functions.

- a. Line graph representation of a database search showing the distribution of cases by age.
- b. Pie graph representation of a database search showing the distribution of cases by age.
- c. Bar graph representation of a database search showing a risk assessment distribution.
- d. Pie graph representation of a database search showing the distribution of procedures by hospital.