



Sloan Consulting

PRODUCTIVITY, QUALITY, INFORMATION AND BUSINESS SYSTEM SOLUTIONS

Breakthrough Case Study in Success

Business Excellence, Lean, Operational Excellence, and Six Sigma use science to solve business problems. Solutions improve profits. Six Sigma's classic **Define, Measure, Analyze, Improve, and Control** (DMAIC) cycle is handy way to summarize success.

“Beating Heart” Coronary Artery Bypass Grafts – The Quintessential Health Care Six Sigma Breakthrough Case Study

Historically speaking, medical “Six Sigma” style breakthroughs have astonished the world. Near zero death rates related to surgical anesthesia and the polio vaccine's safety record are but two near perfect success examples. Sir Austin Bradford Hill's 1951 sentiments sound as fresh as a 21st Century General Electric Six Sigma news release.

“In treating patients with unproved remedies we are, whether we like it or not, experimenting on human beings, and a good experiment well reported may be more ethical and entail less shirking of duty than a poor one.” (Br. Med 2:1088-90, 1951, Hill, 1952)

The ability to consistently replicate experimental outcomes with a high degree of confidence is of paramount importance to everyone in the health care system. Again, off-pump surgical technique provides an ideal compass setting that points the way for current and experimental breakthroughs. Since health care Six Sigma breakthroughs simultaneously improve the profitability, “off-pump” coronary artery bypass grafts (CABG) are as substantive.

Limited financial resources fostered the early 1980's development of “beating heart” CABG surgeries in Argentina. Compelling statistical evidence is leading to the reluctant, gradual acceptance of this surgical technique in competitive 2002 health care markets. Patient demand for this lower cost, higher quality procedure has forced, and is forcing, surgeons to master it as a standard of care rather than an experimental method that has yet to be proved.

The classic **Define, Measure, Analyze, Improve, and Control** cycle provides a convenient way to summarize this story.

Define

For over 40 years, the use of cardiopulmonary bypass (CPB) pumps defined coronary artery bypass grafting (CABG) procedures. Good outcomes and the relative ease of working on an arrested heart led most cardiac surgeons to favor the use of CPB.ⁱ Adverse and statistically significant blood utilization and neurological side effects associated with on-pump surgeries were accepted.

Though evidence suggested off-pump operations were safe and advantageous for select patients, the prevailing paradigms of cardiac surgery sustained physician commitment to the on-pump surgical technique. It has taken a decade for surgical practice patterns to emerge that reflect sentiments expressed by researchers in 1992. “Further research should be directed to which subgroups can be operated on to advantage off pump and which, if any, groups of patients should be confined to on-bypass operations.”ⁱⁱ

Patterns and pattern recognition are key elements in the identification of breakthrough improvements. Database and computing systems accelerate both when they are included in a closed system feedback loop. Figure 1 illustrates the classic, Six Sigma feedback system. Obviously doctors, nurses, allied health professionals, and administrative leaders are the Six Sigma “executives, champions, and Master Black Belt” experts who initiate breakthrough improvement actions.

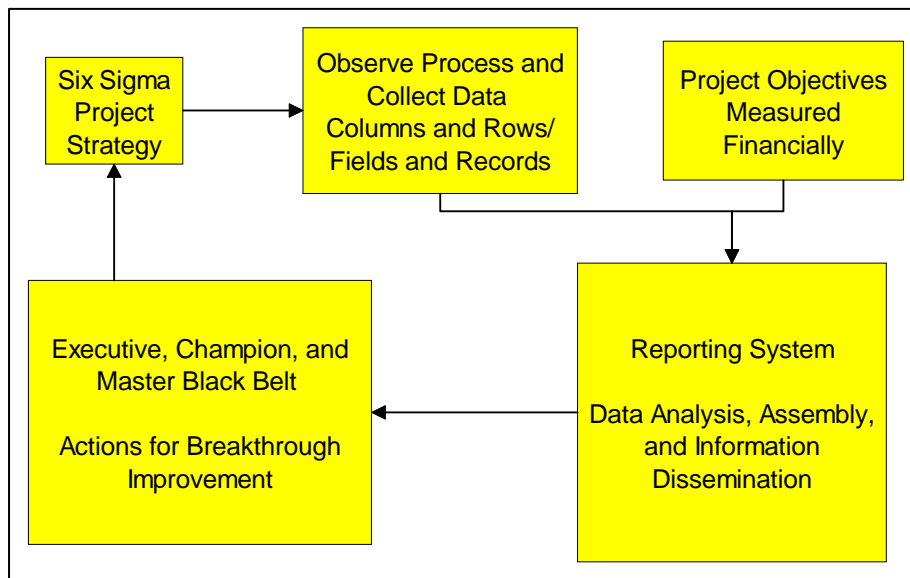


Figure 1 Closed loop feedback system for Six Sigma.

In addition to quantitative feedback measures, qualitative impressions frequently expose opportunities. In the off-pump/on-pump dialogue, one qualitative signal is the long running practice of opinionated debates between surgeons. Without a commitment to Six

Sigma analysis, these discussions are generally sustained without generating statistical evidence for analysis.

Measure and Analyze

Though surgical practice data is often collected by hand, increasingly this data is automatically entered into databases. Integrated statistical software packages now make it possible to analyze measurement data almost as quickly as they are recorded.

Figure 2 shows columns and rows of data for a single cardiac surgeon who, after a number of his patients canceled their scheduled on-pump surgeries in order to have them performed off pump by a different surgeon at a competing hospital, decided to master the off-pump surgical technique.

	On Pump LOS	On Pump Charges	Off Pump LOS	Off Pump Charges	Combined LOS	ANOVA	Combined Charges
1	6	33909	2	24217	7	on	33909
2	8	39233	4	21569	6	on	39233
3	3	22197	3	27493	4	on	22197
4	8	38851	2	26125	7	on	38851
5	4	28243	3	26211	5	on	28243
6	4	28224	3	28242	6	on	28224
7	8	43082	4	23869	7	on	43082
8	6	36359	3	26643	5	on	36359
9	10	73998	3	32668	7	on	73998
10	6	30193	4	30277	11	on	30193
11	5	3586	2	25235	6	on	3586
12	6	32188	3	28329	5	on	32188
13	6	3264	2	23396	5	on	3264
14	5	28390	2	20730	6	on	28390
15	9	39884	3	32433	7	on	39884
16	8	52542	3	35246	9	on	52542
17	5	26428	4	30605	6	on	26428
18	5	33071	3	32391	4	on	33071
19	4	25074	4	32324	3	on	25074
20	4	27532	3	30605	5	on	27532

Figure 2 Sample database used to compare one surgeon’s on-pump and off-pump experience: lengths of stay (LOS) and charges are paired for each patient.

The computerized analysis of length of stay data from this spreadsheet, Figure 3, reflects similar findings contained in 443 peer-reviewed articles published on the on-pump/off-pump subject since 1992. For any individual who wishes to confirm the existence of these studies, the multi-variate statistical methods employed, reliability, and validity of this research, a University of Washington Health Science’s library, or other university library system data base search will yield every one of these abstracts and articles in moments.

The peer-reviewed literature on this topic is consistent to a remarkable degree. Patients who undergo off pump CABG surgeries experience dramatically lower lengths of stay. Literature searches used to cross check statistical inferences are a value added service physicians appreciate.

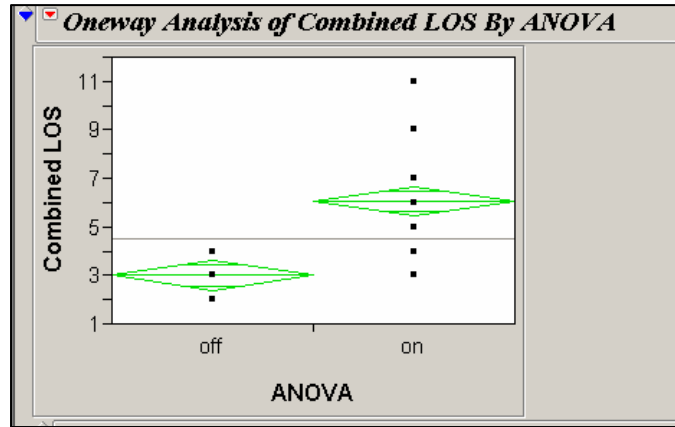


Figure 3 The lengths of stay differences between on pump and off pump surgeries are statistically significant. A higher quality, shorter length of stay is also less costly.

A quality control chart, figure 4, provides another view of the impact off-pump surgical technique brings to the quality of patient care. As the average length of stay shrinks, so does variation around the mean. Since 1931, this pattern has symbolized the classic breakthrough pattern. These breakthroughs now lead to near perfect performances known as Six Sigma.

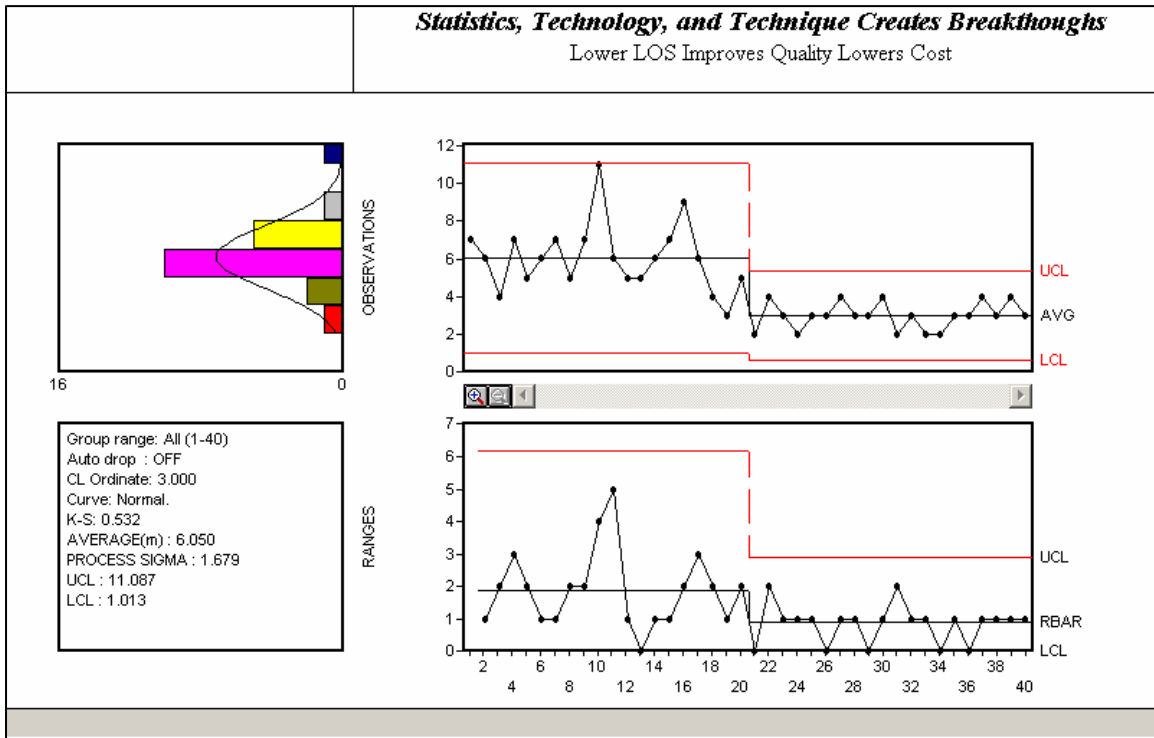


Figure 4 Reductions in patient lengths of stay related to off-pump CABG surgeries are dramatic.

The surgeon’s database was stratified to facilitate a 3-Dimensional statistical analysis to consider the effect a number of other factors might have had on length of stay outcomes.

Factors we considered were diagnostic (ICD) code variations, co-morbidities, age, gender, and race. An example is shown in Figure 5's cube plot. The Cartesian coordinate system's cube is an ideal graphic for presenting multidimensional statistical evidence. The numbers contained in the rectangular boxes at the cube's corners are average values. Even a novice can interpret the results at a glance.

All four of the shortest lengths of stay related to CABG are located on the cube's left plane. The shortest average length of stay, 1.875, was a result of an off-pump surgery with a male patient with ICD code 36.11. All of the longer lengths of stay are located on the cube's right plane. The longest average length of stay, 6.875, was the effect of on pump surgeries for men with ICD code 36.12. Though three factors are presented simultaneously, the only statistically significant factor related to a lower length of stay is a surgery performed off pump.

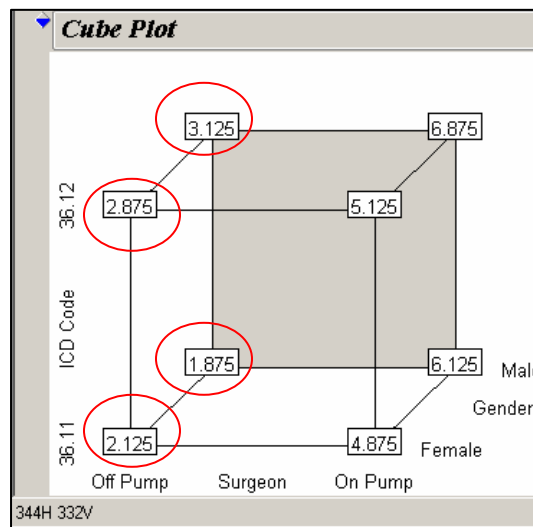


Figure 5 In comparing the surgeon against himself, off pump surgeries had a statistically significant lower length of stay at the 95% level of confidence. Even when co-morbidities, patient age, and other confounding variables were considered, off pump surgeries surfaced as the main effect responsible for shorter lengths of stay. We observed improved patient outcomes and improved profitability as well.

Improve

Sixteen years of experience in promoting breakthrough improvements in health care quality and productivity teach an important lesson. Before changes occur in physician or hospital practice, benefits must be translated into a compelling financial story. Though this reality can be disheartening for caregivers who put patient safety first, leaders must prioritize cost accounting if they expect to see system wide improvements take place.

Simulation modeling using spreadsheet applications are relatively easy tools to master. The psychological impact of seeing 1,000 or more iterations of multivariate spreadsheet

practice scenarios in a matter of moments is significant. More often than not, spreadsheet simulations are persuasive.

Figure 6 shows the variation in financial impact one surgeon can have on a hospital's CABG income. The low end of the distribution suggests that by mastering the off pump procedure for the majority of his or her patients, an additional 448K in revenue would be generated. On the high end of the distribution, this change could produce as much as \$1.45 million.

Actual results fell near the center of the prediction parameters. Savings were achieved through lower nursing care costs and overhead. Off pump patients avoided adverse side effects while the hospital enjoyed improved profitability. These results are classic hallmarks of a Six Sigma style breakthrough.

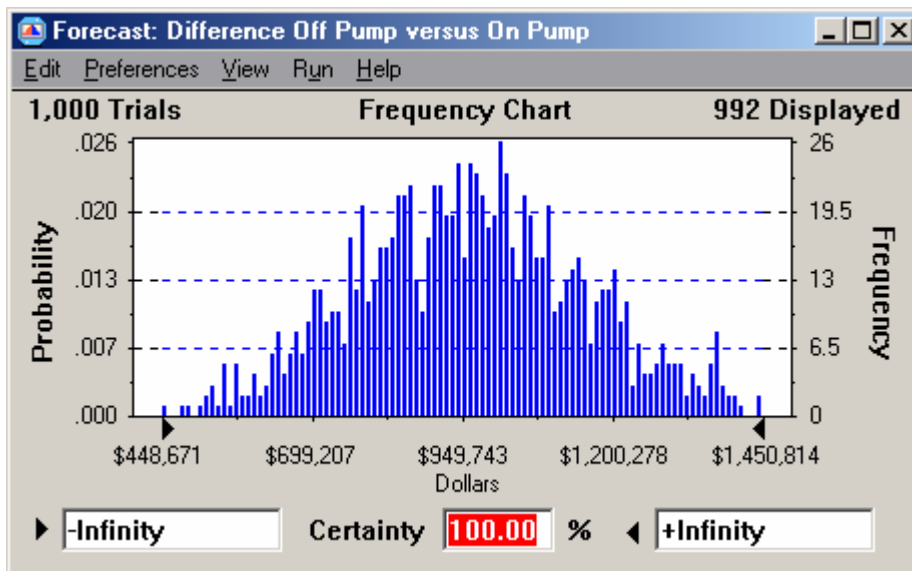


Figure 6 Spreadsheet simulation tools are a compelling, persuasive use of designed experiments and statistical analysis.

Control

The final step in the Six Sigma DMAIC (Define, Measure, Analyze, Improve and Control) process is to standardize breakthroughs and hold the gains. Discipline is as important to success here as it is with each of the other steps.

Leadership and culture determine the rate of adoption for breakthroughs in productivity and quality. When the medical staff and other senior leaders are disciplined and when they role model the use of science, statistical analysis, and systematic experimentation breakthrough improvements occur.

Six Sigma culture evolves along with the breakthroughs. The degree of success in every Six Sigma breakthrough is directly related to the level of commitment that is demonstrated by senior leadership.

ⁱ Pfister, Albert J., Zaki, M. Salah, et al. Coronary Artery Bypass without Cardiopulmonary Bypass. *Ann of Thorac Surg* 1992; 54:1085-92.

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