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VALIDATION OF BOOTSTRAP ESTIMATION OF COMBINED ANESTHESIA AND SURGICAL TIME FOR CARDIAC SURGICAL PROCEDURES

AUTHORS: S. Mantha

AFFILIATION: Anesthesiology and Intensive Care, Nizam's Instiute of Medical Sciences, Hyderabad, India

INTRODUCTION: Parameter (mean/median) estimation of combined anesthesia and surgical time is of particular interest in hospital management studies. Bootstrap (resampling statistics) estimation of confidence intervals of the required parameter is one the recommended methods.[1] Given the high variability of factors determining the combined anesthesia and surgical time in a teaching hospital setting, it is not known whether Bootstrap is the reliable method for parameter estimation. This study sought to validate Bootstrap method for the purpose.

METHODS: The combined anesthesia and surgical time in minutes was calculated from start of placement of monitoring lines for anesthesia to the end of surgery. Five-year data from 2006 to 2010 in a particular cardiac surgical suite of a University hospital represented the population. The elective cardiac surgical procedures with 5-year data exceeding 200 were included. For each surgical procedure, a sample with a size of 10 was drawn randomly from the population. The sample was resampled with replacement. The mean and median time of each resampled data were computed. This resampling with replacement was repeated 1000 times. The Bootstrap mean and median and their respective 95% confidence interval based on 2.5th and 97.5th percentiles of the distributions were obtained. This process was repeated 100 times (trials) for each surgical procedure. The confidence intervals obtained in each of the 100 trials were examined whether they correctly estimated the population parameter. A macro (computer code to perform tedious repetitive tasks) was developed for Minitab 16 for windows (©2010 Minitab Inc.) to facilitate the analysis.

RESULTS: The results (Table) imply that this Bootstrap method is reliable to estimate the population parameters (mean and median) for the combined anesthesia and surgical time. The method estimates the median more correctly as opposed to the mean time.

DISCUSSION: Small sample size and variability in the samples are important factors that determine the reliability of parameter estimation. Even within a defined cardiac surgical procedure, underlying pathology contributes to variability in the operating time. The variability of combined anesthesia and surgical time may also result from issues related to resident training in anesthesia and cardiac surgery inherent in University centers. The results validate the use Bootstrap method with a sample size as small as 10 to estimate the population parameter.

REFERENCES:

1. DiCiccio TJ, Efron B. Bootstrap confidence intervals. Statistical Science. 1996:;3:189-228

Population Parameters and Resampling Trial Data of Combined Anesthesia and Surgical Time for Cardiac Surgical Procedures

Procedure	Population	Population	% of trials (n=100) that	% of trials (n=100) that
Procedure (N)	Population Mean time (min) (SD)	Population Median time (min) (IQR)	% of trails (n=100) that correctly estimated mean time	% of trials (n=100) that correctly estimated median time
CABG (921)	343 (73)	330 (300 to 390)	88%	94%
MVR (288)	265 (56)	255 (230 to 300)	91%	96%
ICR (254)	314 (85)	300 (260 to 360)	87%	98%
ASD (223)	215 (53)	210 (180 to 240)	93%	98%

CABG: On-pump coronary artery bypass graft, MVR: mitral valve replacement, ICR: Intracardiac repair typically for tetraology of Fallot, ASD: Closure of atrial septal defect. N: Five-year data representing the population.

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Srinivas Mantha, MD

Dept. of Anesthesiology, Nizam's Institute of Medical Sciences, Hyderabad, India

Abstract

Introduction: Parameter (mean/median) estimation of combined anesthesia and surgical time is of particular interest in hospital management studies. Bootstrap (resampling statistics) estimation of confidence intervals of the required parameter is one the recommended methods. [1] Given the high variability of factors determining the combined anesthesia and surgical time in a teaching hospital setting, it is not known whether Bootstrap is the reliable method for parameter estimation. This study sought to validate Bootstrap method for the purpose.

Methods: The combined anesthesia and surgical time in minutes was calculated from start of placement of monitoring lines for anesthesia to the end of surgery. Five-year data from 2006 to 2010 in a particular cardiac surgical suite of a University hospital represented the population. The elective cardiac surgical procedures with 5-year data exceeding 200 were included. For each surgical procedure, a sample with a size of 10 was drawn randomly from the population. The sample was resampled with replacement. The mean and median time of each resampled data were computed. This resampling with replacement was repeated 1000 times. The Bootstrap mean and median and their respective 95% confidence interval based on 2.5th and 97.5th percentiles of the distributions were obtained. This process was repeated 100 times (trials) for each surgical procedure. The confidence intervals obtained in each of the 100 trials were examined whether they correctly estimated the population parameter. A macro (computer code to perform tedious repetitive tasks) was developed for Minitab 16 for windows (© 2010 Minitab Inc.) to facilitate the analysis.

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Table: Population Parameters and Resampling Trial Data of Combined Anesthesia and Surgical Time for Cardiac Surgical Procedures

Procedure (N)	Population Mean time min (SD)	Population median time IQR	Correct estimation of mean time (% trials)	Correct estimation of median time (% trials)
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CABG (coronary artery bypass graft), MVR (mitral valve replacement), ICR (intracardiac repair), ASD (atrail septal defect), N; 5-yr data (Population)

Introduction and Methods

Introduction

Parameter (mean/median) estimation of combined anesthesia and surgical time is of particular interest in hospital management studies. The estimated times may be highly variable imposed by teaching and training components in teaching hospital settings.

Bootstrap (resampling statistics) estimation of confidence intervals of the required parameter is one the recommended methods. [1] Given the high variability of factors determining the combined anesthesia and surgical time in a teaching hospital setting, it is not known whether Bootstrap is the reliable method for parameter estimation. This study sought to validate Bootstrap method for the purpose.

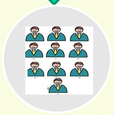
Methods:

- The combined anesthesia and surgical time in minutes was calculated from start of placement of monitoring lines for anesthesia to the end of surgery.
- Five-year data from 2006 to 2010 in a particular cardiac surgical suite of a University hospital represented the population.
- The elective cardiac surgical procedures with 5-year data exceeding 200 were included.
- The following are the steps involved in the validation of resampling method stated in the hypothesis.

1. For each surgical procedure, a sample with a size of 10 was drawn randomly from the population.
2. The sample was resampled with replacement. The mean and median time of each resampled data were computed.
3. This resampling with replacement was repeated 1000 times.
4. The Bootstrap mean and median and their respective 95% confidence interval based on 2.5th and 97.5th percentiles of the distributions were obtained.
   http://www.stat.wmich.edu/s160/book/node48.html
5. This process was repeated 100 times (trials) for each surgery.
6. The confidence intervals obtained in each of the 100 trials were examined whether they correctly estimated the population parameter.

Methods (Example)

Population (5-yr data) CABG



Random sample (n=10)

The sample is resampled with replacement 1000 times

Data	sample	RS1	RS2	RS3	RS4	RS5	>>>	RS 1000
1	250	300	315	435	295	360		315
2	295	295	420	410	360	315		410
3	315	420	315	360	360	315		250
4	315	315	315	300	410	250		315
5	420	295	300	295	435	420		435
6	435	300	295	435	300	250		410
7	360	295	300	435	295	300		315
8	410	420	420	300	315	300		360
9	300	410	250	250	250	300		315
10	300	410	250	315	435	435		300
Mean	340	346	318	353	345	324		342
Median	315	307	307	337	337	307		315

Bootstrap Sample	Mean Time	Median Time
1	287.5	275
2	288	295
3	291	295
↓	↓	↓
↓	↓	↓
25	300.5	297.5
↓	↓	↓
↓	↓	↓
↓	↓	↓
500	331.5	315
↓	↓	↓
↓	↓	↓
↓	↓	↓
975	363	362.5
↓	↓	↓
↓	↓	↓
998	379	410
999	379	410
1000	401	420

- The Bootstrap mean and median and their respective 95% confidence interval based on 2.5th and 97.5th percentiles of the distributions were obtained.
- Refer to the website link for details of computation of Bootstrap confidence interval
- This process was repeated 100 times (trials) for each surgery.

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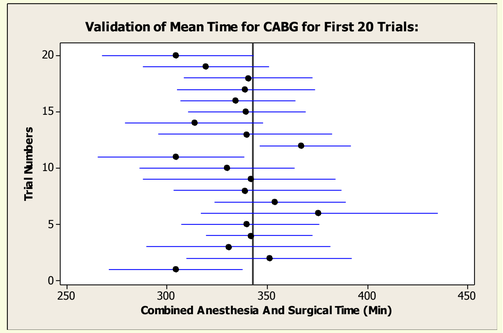
A macro (computer code to perform tedious repetitive tasks) was developed for Minitab 16 for windows (© 2010 Minitab Inc.) to facilitate the analysis

Methods (Example)

Fig 1: Example for validation of mean time for CABG

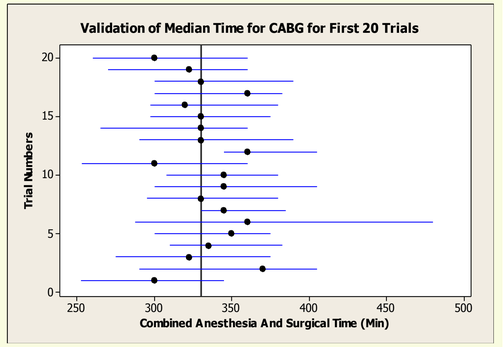
(Population mean combined anesthesia and surgical time for CABG: 343 min)



Confidence intervals of Trial numbers 1, 11, and 12 not estimated population parameter correctly

Fig 2: Example for validation of median time for CABG

(Population median combined anesthesia and surgical time for CABG: 330 min)



Confidence intervals of Trial number 12 not estimated population parameter correctly

Results, Discussion and References

Results: The results (Table) imply that

- Bootstrap method is reliable to estimate the population parameters (mean and median) for the combined anesthesia and surgical time.
- The method estimates the median more correctly as opposed to the mean time.

Table: Population Parameters and Resampling Trial Data of Combined Anesthesia and Surgical Time for Cardiac Surgical Procedures

Procedure (N)	Population Mean time min (SD)	Population median time min (IQR)	Correct estimation of mean time (% trials)	Correct estimation of median time (% trials)
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CABG (coronary artery bypass graft),
MVR (mitral valve replacement),
ICR (intracardiac repair),
ASD (atrail septal defect),
N; 5-yr data Representing Population

Discussion: :

- Small sample size and variability in the samples are important factors that determine the reliability of parameter estimation.
- Even within a defined cardiac surgical procedure, underlying pathology contributes to variability in the operating time.
- The variability of combined anesthesia and surgical time may also result from issues related to resident training in anesthesia and cardiac surgery inherent in University centers.
- The results validate the use Bootstrap method with a sample size as small as 10 to estimate the population parameter.

References:

1. DiCiccio TJ, Efron B. Bootstrap confidence intervals. Statistical Science. 1996; 3:189-228