OUT OF THE (FEEDBACK) LOOP: WHAT THE BIG APPLE HAS LEARNED ABOUT QUALITY CPR

John Freese, MD
Chief Medical Director
Fire Department of New York (FDNY)


SECRET BOX
WAIT FOR KEY
NOT TO BE OPENED
SECRET BOX

Background

NYC Cardiac Arrest Survival

- **PHASE study**
- **Dr. Gary Lombardi**
- **1994, JAMA**

Outcome of Out-of-Hospital Cardiac Arrest in New York City

The Pre-Hospital Arrest Survival Evaluation (PHASE) Study

Gary Lombardi, MD; E. John Gallagher, MD; Paul Gennis, MD

Objective.—To determine survival from out-of-hospital cardiac arrest in New York City and to compare this with other urban, suburban, and rural areas.

Design.—Observational cohort study.

Setting.—New York City.

Participants.—Consecutive out-of-hospital cardiac arrests occurring between October 1, 1990, and April 1, 1991.

Intervention.—Trained paramedics performed immediate postarrest interviews with care providers, using a standardized questionnaire.

Main Outcome Measures.—Entry criteria, elapsed time intervals, and nodal events conformed to Utstein recommendations. The single target end point was death or discharge home.

Results.—Of 3243 consecutive cardiac arrests on which resuscitation was attempted, 2329 (72%) met entry criteria as primary cardiac events. Overall survival was 1.4% (99% confidence interval [CI], 0.9% to 2.3%). No patients were lost to follow-up. Survival from witnessed ventricular fibrillation was 5.3% (99% CI, 2.9% to 8.8%). Using survival from witnessed ventricular fibrillation for intersystem comparison, our survival rate was similar to that of Chicago, Ill (4.0%; 99% CI, 1.9% to 7.5%; $P=.41$), the only other large city on which data were available. However, it was significantly lower than that reported from midsized urban/suburban areas (33.0%; 99% CI, 30.4% to 35.6%; $P<.0001$) and suburban/rural areas (12.6%; 99% CI, 8.9% to 16.3%; $P<.0001$). Survival rate among arrests occurring after arrival of emergency medical services personnel (8.5%; 99% CI, 4.7% to 14.0%) was comparable with Chicago (6.6%; 99% CI, 3.3% to 11.5%; $P=.41$) but markedly lower than King County, Washington (36%; 99% CI, 28.6% to 43.8%; $P<.0001$).

Conclusions.—Survival from out-of-hospital cardiac arrest in New York City was poor. This was partly attributable to lengthy elapsed time intervals at every step in the chain of survival. However, examination of survival among arrests occurring after emergency medical services arrival suggests that other features may predispose residents of large cities to higher cardiac arrest mortality than individuals living in more suburban or rural settings. Since half the US population resides in large metropolitan areas, this represents a public health problem of considerable magnitude.

(*JAMA*. 1994;271:678-683)

THE MAJORITY of cardiac arrests in the United States occur outside the hospital.[1-3] Because half the nation resides in cities of more than 1 million population,[4] most arrests take place in large urban settings. Despite this, only one US city with a census exceeding 1 million has reported survival on a population-based series of out-of-hospital cardiac arrests.[5]

The Pre-Hospital Arrest Survival Evaluation (PHASE) study was designed to determine survivorship from cardiac arrest in New York City by collecting a consecutive series of all verified arrests occurring within city boundaries and following up with all members of the cohort until death or discharge home.

From the Departments of Medicine, Epidemiology, and Social Medicine, Albert Einstein College of Medicine, Bronx, NY. During 1 year of the project, Dr Gallagher was a Visiting Clinical Scholar, Robert Wood Johnson Clinical Scholars Program, Yale University School of Medicine, New Haven, Conn.

Reprint requests to Emergency Department 1-W-20, Bronx Municipal Hospital, Bronx, NY 10461 (Dr Gallagher).

METHODS

System Configuration

New York City encompasses 782 km² with a resident population of 7 332 564.[6] The New York City 911 telephone system dispatches about 1 million medical calls annually, resulting in transport of patients to 61 receiving hospitals. There are four components in the system: (1) The municipal ambulance service (New York City Emergency Medical Services [EMS]), (2) the voluntary hospital ambulances, (3) the volunteer ambulance corps, and (4) the commercial ambulance companies. New York City EMS is the nation's largest emergency medical service, providing 473 eight-hour ambulance tours daily. It is a two-tiered system, comprising approximately 650 paramedics and 1700 emergency medical technician-defibrillators. The voluntary hospitals contribute an additional 110 ambulance tours daily. The distribution of all ambulance assets is 138 units overnight, 220 units for daytime, and 235 units on evening tours. Because the volunteer and commercial ambulances are not accessed or dispatched through the 911 telephone system and infrequently handle cardiac arrests, we excluded patients treated by these services from our study by design.

Data Collection

Six experienced paramedics were employed full-time by the PHASE project. Immediately following a suspected cardiac arrest, the PHASE medics contacted the field units involved in the case. A structured postarrest interview with EMS personnel and hospital emergency departments was then conducted by the PHASE medics, using an 89-item

Background

PHASE Study

- Dr. Gary Lombardi
- 1994, JAMA
- Overall survival = 1.4%
- Survival (witnessed, cardiac)
  - ROSC: 28.2%
  - admission: 15.5%
  - discharge: 2.1%

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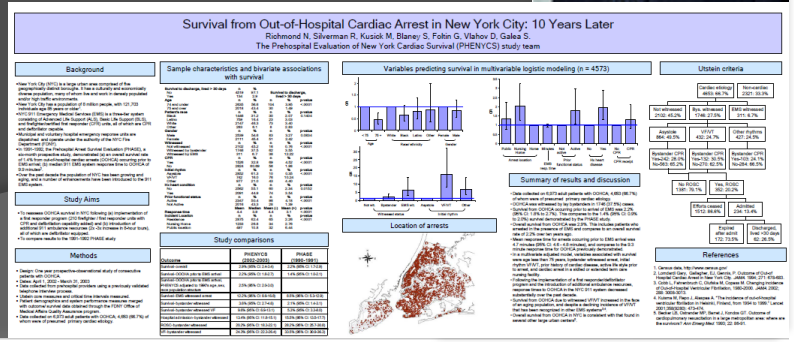
Background

NYC Cardiac Arrest Survival

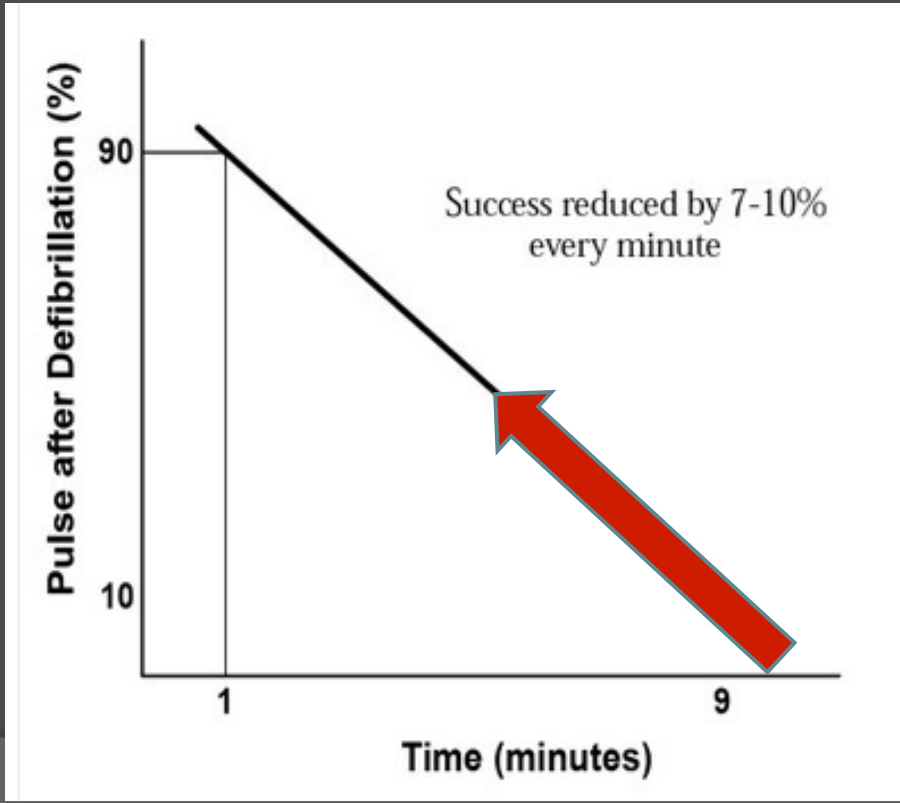
- **PHENYCS study**
- **Dr. Neal Richmond**
- **merger of EMS and FDNY**
- **cost > $1 billion**
- **increased AEDs**
- **2-3x increase in ambulances**

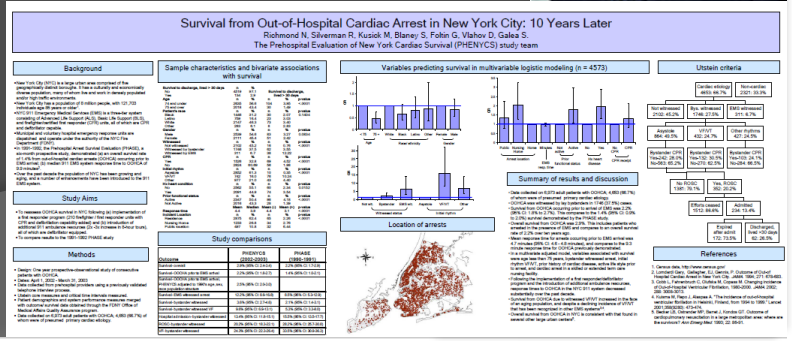


Background

PHENYCS Study

- **Dr. Neal Richmond**
- **response time 11.4 minutes → 4.7 minutes**





Background

	PHASE	PHENYCS
Overall Survival	1.4%	
Bystander Witnessed, Cardiac Etiology		
ROSC	28.2%	
Admission	15.5%	
Discharge	2.1%	

Background

	PHASE	PHENYCS
Overall Survival	1.4%	2.2%
Bystander Witnessed, Cardiac Etiology		
ROSC	28.2%	20.2%
Admission	15.5%	13.4%
Discharge	2.1%	3.6%

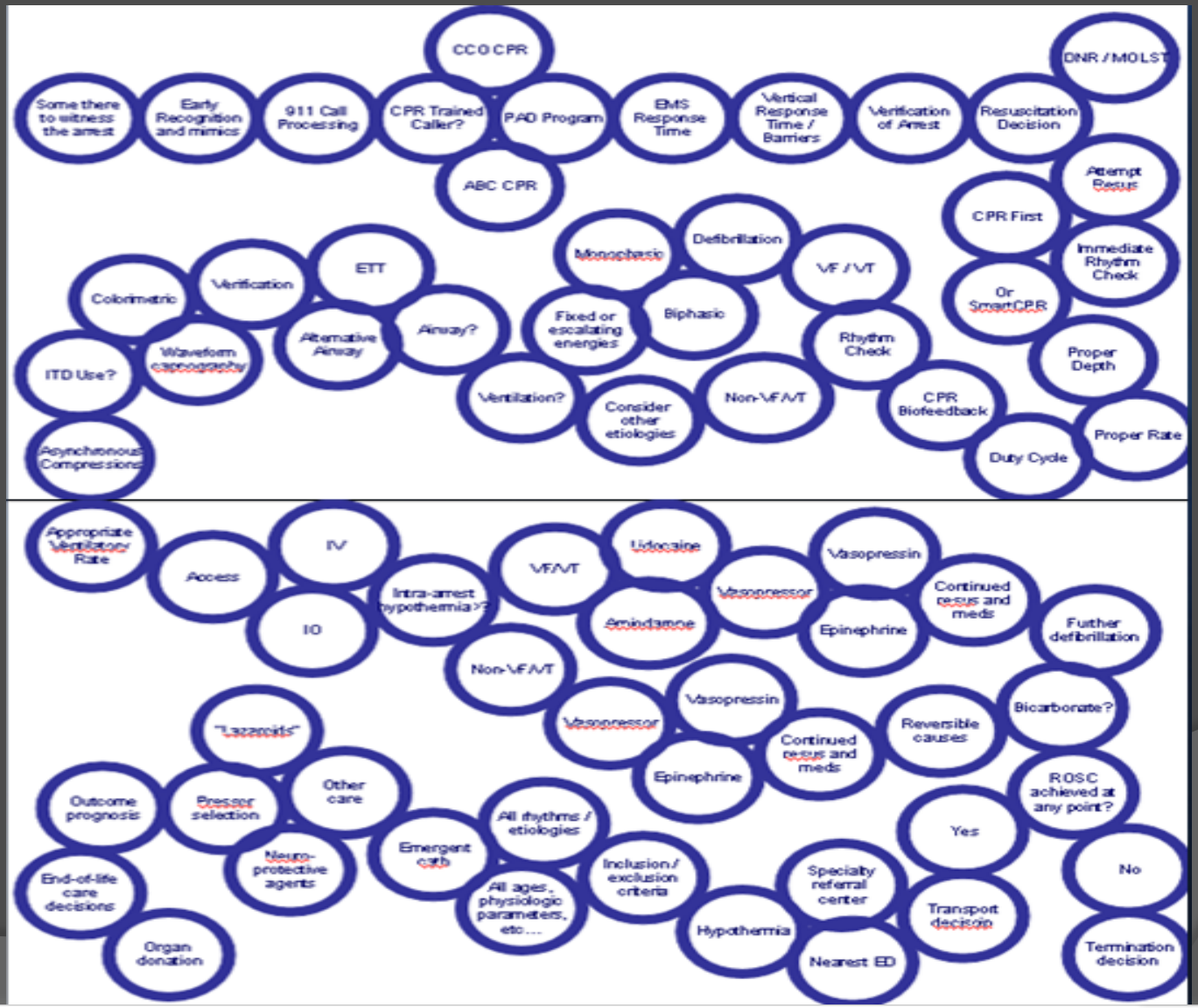
Feedback Loop

NYC Cardiac Arrest Survival

Background


Chain of survival
Early recognition and call for help
- to prevent cardiac arrest
Early CPR
- to buy time
Early Defibrillation
- to restart the heart
Post resuscitation care
- to restore quality of life

Background


CCO CPR
DNR / MOLST
Some there to witness the arrest
Early Recognition and mimics
911 Call Processing
CPR Trained Caller?
PAD Program
EMS Response Time
Vertical Response Time / Barriers
Verification of Arrest
Resuscitation Decision
ABC CPR
Attempt Resus
CPR First
Immediate Rhythm Check
Or SmartCPR
Defibrillation
Monophasic
VF / VT
Biphasic
Fixed or escalating energies
Rhythm Check
ETT
Verification
Colorimetric
Waveform capnography
Alternative Airway
Airway?
ITD Use?
Asynchronous Compressions
Ventilation?
Consider other etiologies
Non-VF/VT
CPR Biofeedback
Proper Depth
Duty Cycle
Proper Rate
Appropriate Ventilatory Rate
Access
IV
IO
Intra-arrest hypothermia?
VF/VT
Lidocaine
Amiodarone
Vasopressor
Vasopressin
Epinephrine
Continued resus and meds
Further defibrillation
Non-VF/VT
Vasopressor
Vasopressin
Epinephrine
Continued resus and meds
Reversible causes
Bicarbonate?
"Lazaroids"
Outcome prognosis
Pressor selection
Other care
Neuro-protective agents
Emergent cath
All rhythms / etiologies
All ages, physiologic parameters, etc....
Inclusion / exclusion criteria
Hypothermia
Specialty referral center
Nearest ED
Transport decision
ROSC achieved at any point?
Yes
No
Termination decision
End-of-life care decisions
Organ donation

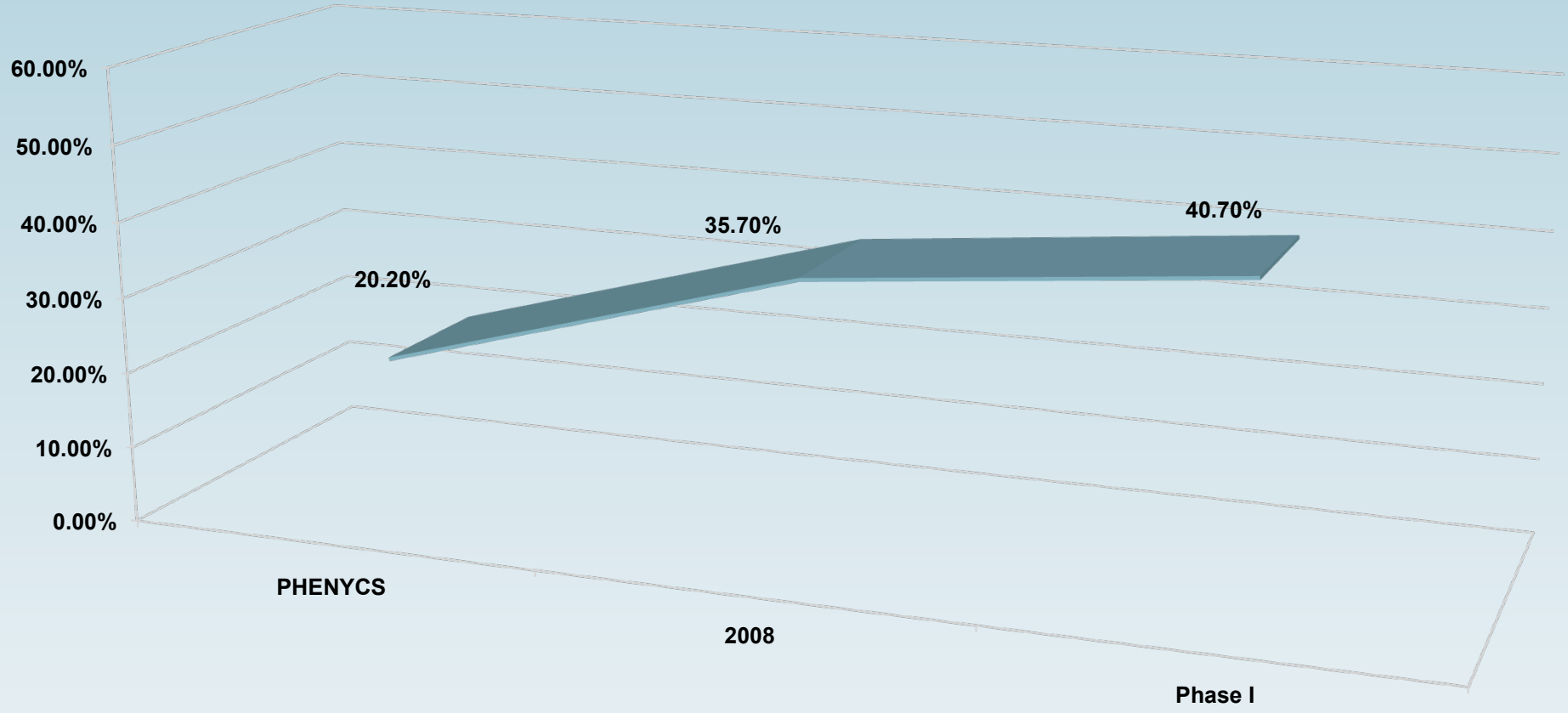
Background

	PHASE	PHENYCS	2008
Overall Survival	1.4%	2.2%	
Bystander Witnessed, Cardiac Etiology			
ROSC	28.2%	20.2%	
Admission	15.5%	13.4%	
Discharge	2.1%	3.6%	

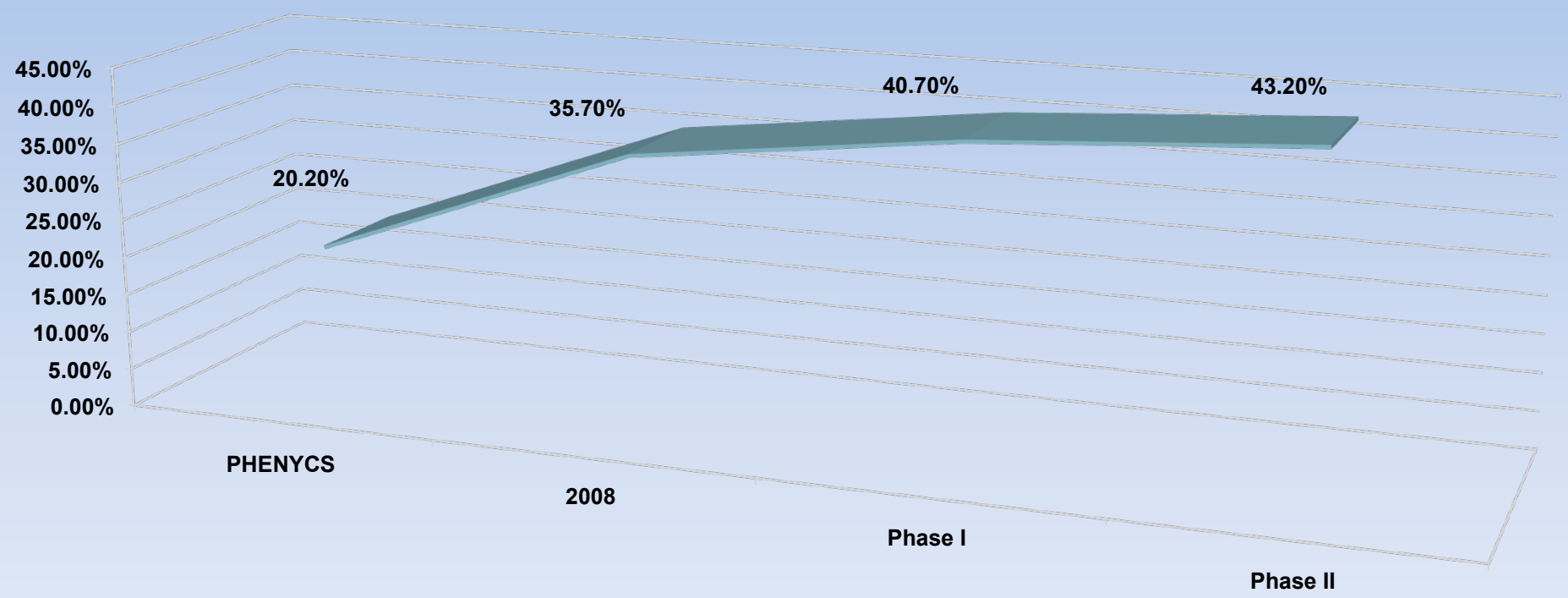
Background

	PHASE	PHENYCS	2008
Overall Survival	1.4%	2.2%	4.2%**
Bystander Witnessed, Cardiac Etiology			
ROSC	28.2%	20.2%	35.7%
Admission	15.5%	13.4%	19.7%**
Discharge	2.1%	3.6%	7.5%**

Background


60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
20.20%
35.70%
40.70%
PHENYCS
2008
Phase I

Background


45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
20.20%
35.70%
40.70%
43.20%
PHENYCS
2008
Phase I
Phase II

Feedback Loop

What defines quality CPR (compressions)?

Feedback Loop

Quality CPR

compression rate

+

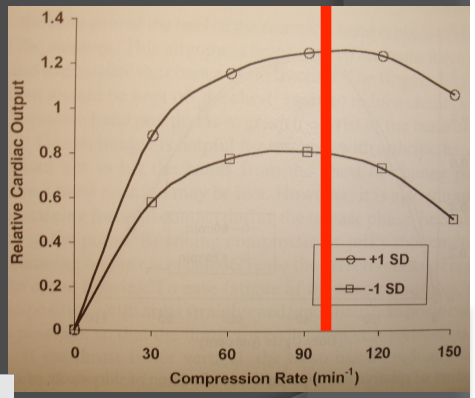
<u>limited interruptions</u>

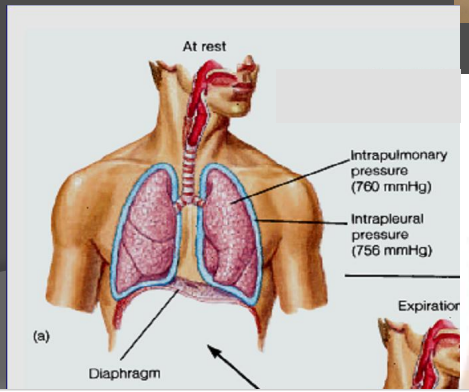
compression fraction

- compression depth

- complete release

- limited ventilation





Feedback Loop

Q: "There's been a lot of talk about compression fraction, and I'm wondering – can you tell us how quickly you get that information back to your providers?"

Feedback Loop

Episode Summary:

Episode start time	1/14/2011 7:37:58 PM
Total length of episode	01:07:10.4
Total number of shocks	0
Time device on	1/14/2011 7:36:51 PM
Time device off	1/14/2011 8:49:02 PM
Total time excluded from statistical calculations	00:00:00.0

Compression Data:

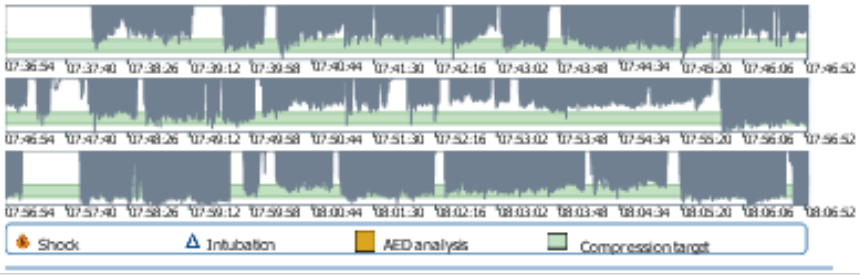
Total number of compressions	5793
Total compressions with adequate depth	4143
Total compressions with insufficient depth	1650
Total compressions with incomplete release	437
Average compression rate [/min] (90-120)	134
Average compression depth [mm] (38-51)	45
Adequate depth [%]	71.5
Average compression counts [/min]	86

No Flow Time:

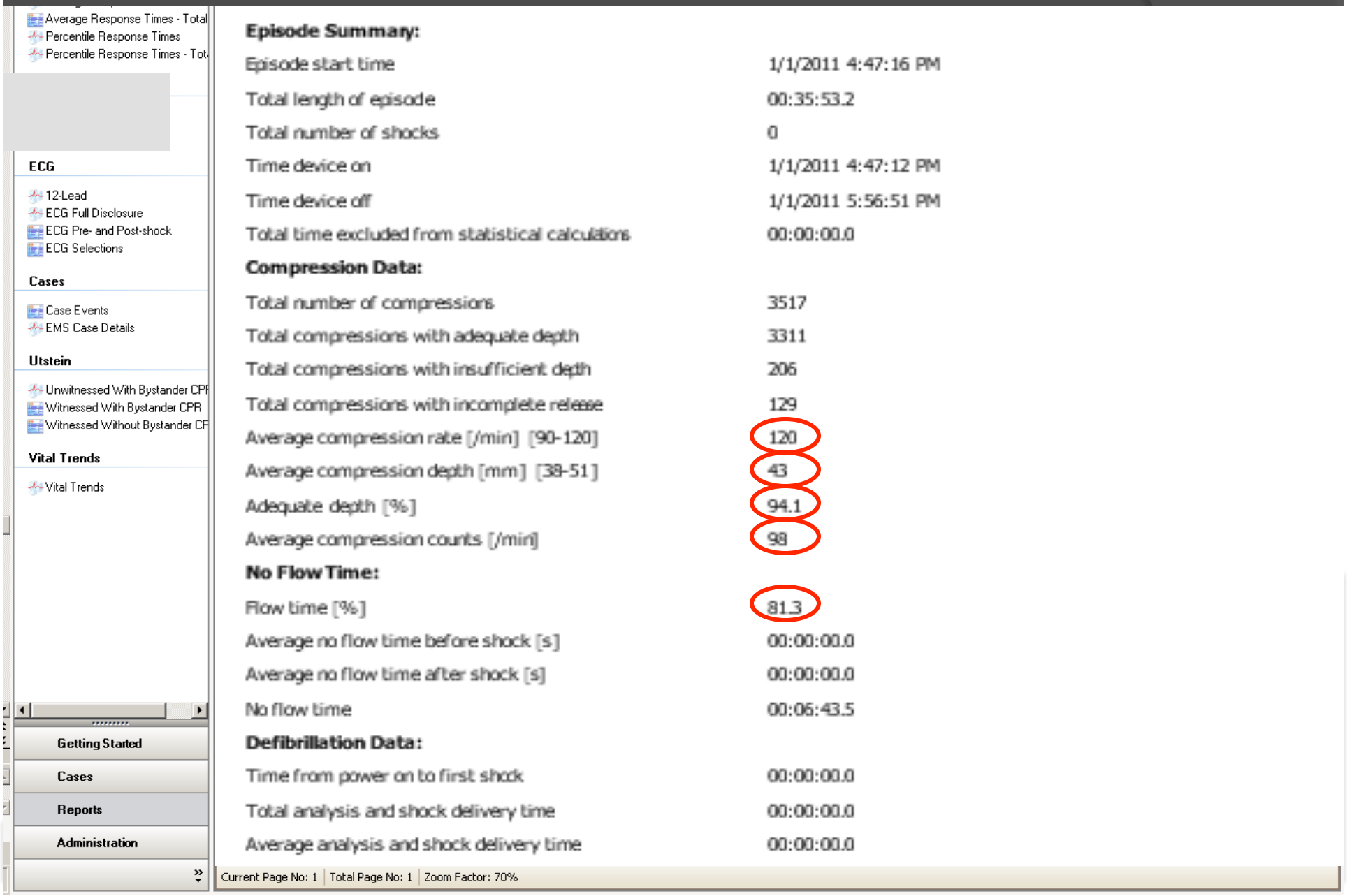
Flow time [%]	63.7
Average no flow time before shock [s]	00:00:00.0
Average no flow time after shock [s]	00:00:00.0
No flow time	00:24:21.8

Defibrillation Data:

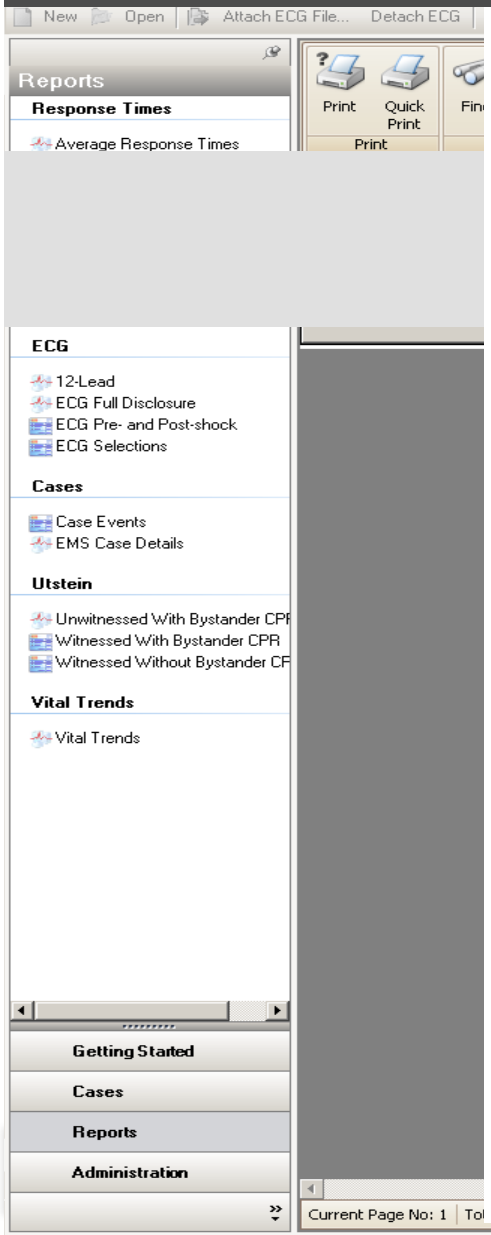
Time from power on to first shock	00:00:00.0
Total analysis and shock delivery time	00:00:00.0
Average analysis and shock delivery time	00:00:00.0



Feedback Loop



Feedback Loop



Episode Summary:

Episode start time	1/8/2011 3:25:17 PM
Total length of episode	00:31:22.7
Total number of shocks	0
Time device on	1/8/2011 3:24:35 PM
Time device off	1/8/2011 4:33:08 PM
Total time excluded from statistical calculations	00:00:00.0

Compression Data:

Total number of compressions	2350
Total compressions with adequate depth	161
Total compressions with insufficient depth	2189
Total compressions with incomplete release	157
Average compression rate [/min] [90-120]	145
Average compression depth [mm] [38-51]	25
Adequate depth [%]	6.9
Average compression counts [/min]	75

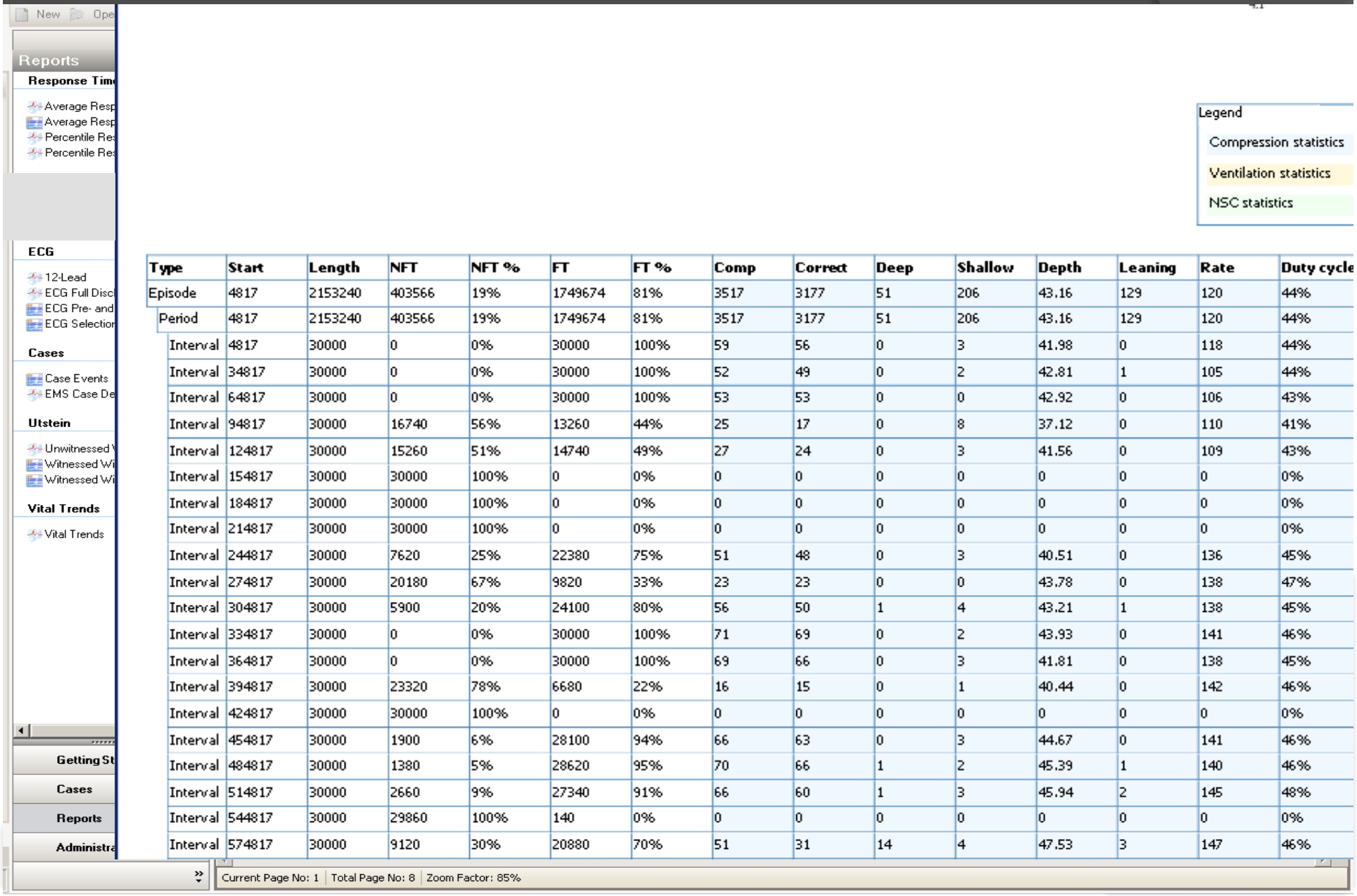
No Flow Time:

Flow time [%]	50.6
Average no flow time before shock [s]	00:00:00.0
Average no flow time after shock [s]	00:00:00.0
No flow time	00:15:30.8

Defibrillation Data:

Time from power on to first shock	00:00:00.0
Total analysis and shock delivery time	00:00:00.0
Average analysis and shock delivery time	00:00:00.0

Feedback Loop



Type	Start	Length	NFT	NFT %	FT	FT %	Comp	Correct	Deep	Shallow	Depth	Leaning	Rate	Duty cycle
Episode	4817	2153240	403566	19%	1749674	81%	3517	3177	51	206	43.16	129	120	44%
Period	4817	2153240	403566	19%	1749674	81%	3517	3177	51	206	43.16	129	120	44%
Interval	4817	30000	0	0%	30000	100%	59	56	0	3	41.98	0	118	44%
Interval	34817	30000	0	0%	30000	100%	52	49	0	2	42.81	1	105	44%
Interval	64817	30000	0	0%	30000	100%	53	53	0	0	42.92	0	106	43%
Interval	94817	30000	16740	56%	13260	44%	25	17	0	8	37.12	0	110	41%
Interval	124817	30000	15260	51%	14740	49%	27	24	0	3	41.56	0	109	43%
Interval	154817	30000	30000	100%	0	0%	0	0	0	0	0	0	0	0%
Interval	184817	30000	30000	100%	0	0%	0	0	0	0	0	0	0	0%
Interval	214817	30000	30000	100%	0	0%	0	0	0	0	0	0	0	0%
Interval	244817	30000	7620	25%	22380	75%	51	48	0	3	40.51	0	136	45%
Interval	274817	30000	20180	67%	9820	33%	23	23	0	0	43.78	0	138	47%
Interval	304817	30000	5900	20%	24100	80%	56	50	1	4	43.21	1	138	45%
Interval	334817	30000	0	0%	30000	100%	71	69	0	2	43.93	0	141	46%
Interval	364817	30000	0	0%	30000	100%	69	66	0	3	41.81	0	138	45%
Interval	394817	30000	23320	78%	6680	22%	16	15	0	1	40.44	0	142	46%
Interval	424817	30000	30000	100%	0	0%	0	0	0	0	0	0	0	0%
Interval	454817	30000	1900	6%	28100	94%	66	63	0	3	44.67	0	141	46%
Interval	484817	30000	1380	5%	28620	95%	70	66	1	2	45.39	1	140	46%
Interval	514817	30000	2660	9%	27340	91%	66	60	1	3	45.94	2	145	48%
Interval	544817	30000	29860	100%	140	0%	0	0	0	0	0	0	0	0%
Interval	574817	30000	9120	30%	20880	70%	51	31	14	4	47.53	3	147	46%

Feedback Loop

Case ID:	1101311028495cc0	**Patient ID:**	
Case date:	1/31/2011	**First name:**	
Device:	HeartStart MRx: US00543125	**Last name:**	

Episode Summary:

Episode start time	1/31/2011 10:29:51 AM
Total length of episode	00:11:36.9
Total number of shocks	1
Time device on	1/31/2011 10:28:49 AM
Time device off	1/31/2011 10:45:08 AM
Total time excluded from statistical calculations	00:00:00.0

Compression Data:

Total number of compressions	780
Total compressions with adequate depth	222
Total compressions with insufficient depth	558
Total compressions with incomplete release	14
Average compression rate [/min] [90-120]	121
Average compression depth [mm] [38-51]	31
Adequate depth [%]	28.5
Average compression counts [/min]	67

No Flow Time:

Flow time [%]	54.2
Average no flow time before shock [s]	00:00:16.2
Average no flow time after shock [s]	00:01:04.2
No flow time	00:05:19.4

Case ID:	1101301711375fe0	**Patient ID:**	
Case date:	1/30/2011	**First name:**	
Device:	HeartStart MRx: US00543193	**Last name:**	

Episode Summary:

Episode start time	1/30/2011 5:11:41 PM
Total length of episode	00:33:05.6
Total number of shocks	7
Time device on	1/30/2011 5:11:37 PM
Time device off	1/30/2011 5:49:41 PM
Total time excluded from statistical calculations	00:00:00.0

Compression Data:

Total number of compressions	2565
Total compressions with adequate depth	1897
Total compressions with insufficient depth	668
Total compressions with incomplete release	29
Average compression rate [/min] [90-120]	109
Average compression depth [mm] [38-51]	41
Adequate depth [%]	74
Average compression counts [/min]	78

No Flow Time:

Flow time [%]	70.1
Average no flow time before shock [s]	00:00:14.4
Average no flow time after shock [s]	00:00:05.7
No flow time	00:09:52.8

Feedback Loop

Feedback Loop

CPR Feedback

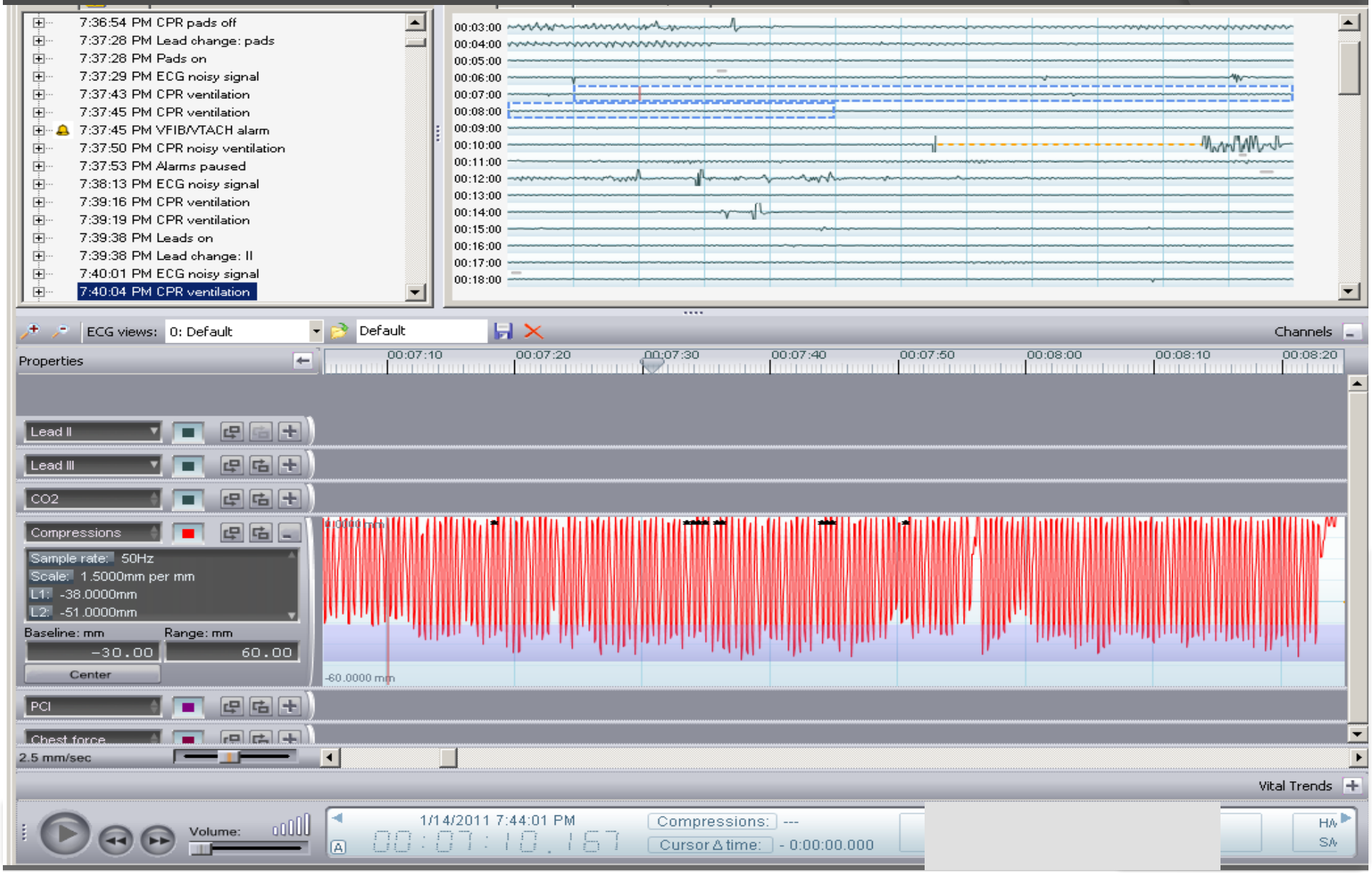
"The quality of unprompted CPR in both in-hospital and out-of–hospital cardiac arrest events is often poor, and methods should be developed to improve the quality of CPR delivered to victims of cardiac arrest.[73,91–93,287] Several studies have demonstrated improvement in chest compression rate, depth, chest recoil, ventilation rate, and indicators of blood flow such as end-tidal CO2 (PETCO2) when real-time feedback or prompt devices are used to guide CPR performance.[72,73,80,288–293] However, there are no studies to date that demonstrate a significant improvement in patient survival related to the use of CPR feedback devices during actual cardiac arrest events. Other CPR feedback devices with accelerometers may overestimate compression depth when compressions are performed on a soft surface such as a mattress because the depth of sternal movement may be partly due to movement of the mattress rather than anterior-posterior (AP) compression of the chest.[62,294] Nevertheless, real-time CPR prompting and feedback technology such as visual and auditory prompting devices can improve the quality of CPR (Class IIa, LOE B)."

Feedback Loop

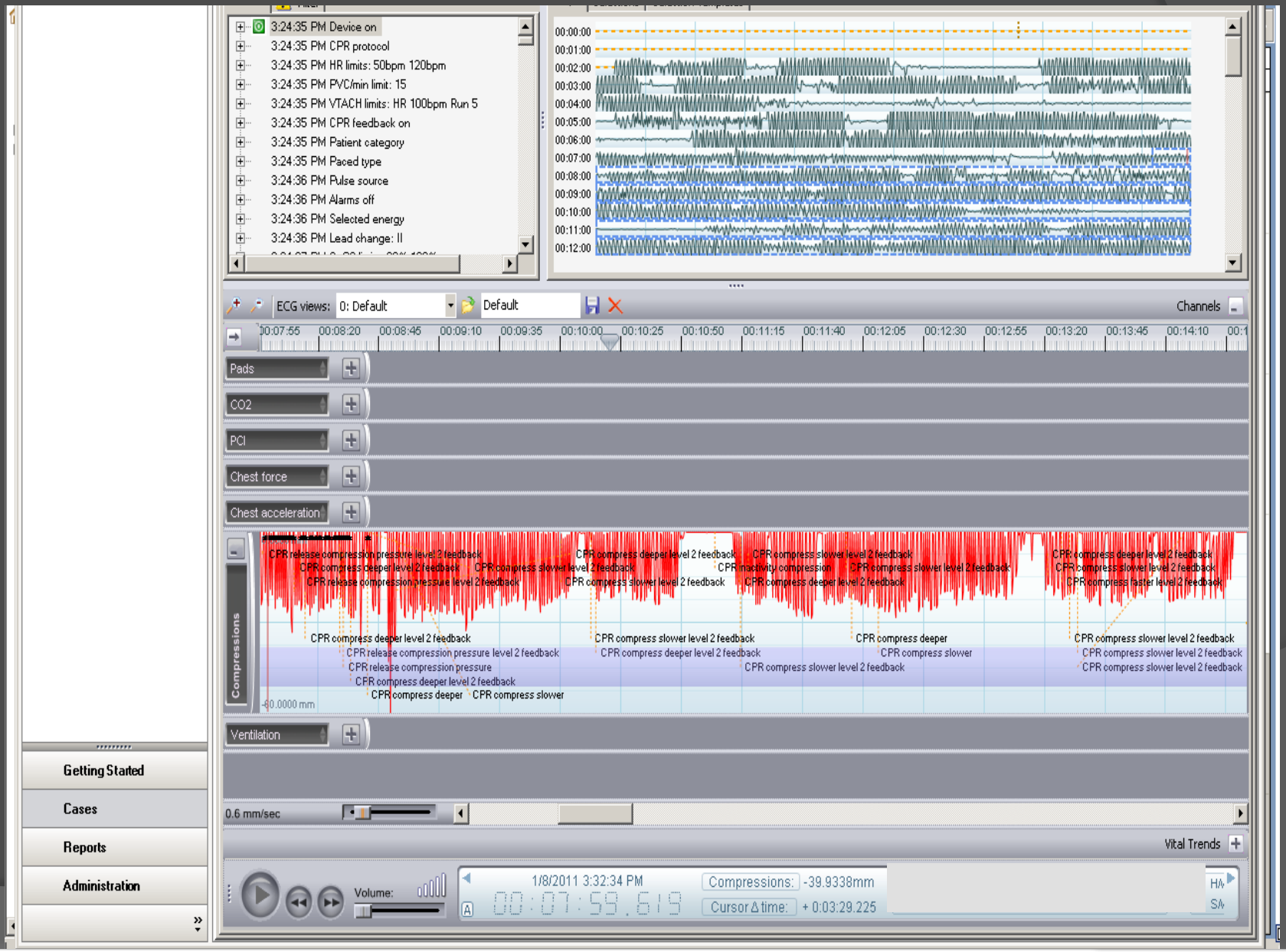
Q: "There's been a lot of talk about compression fraction, and I'm wondering – can you tell us how quickly you get that information back to your providers?"

A: Immediately

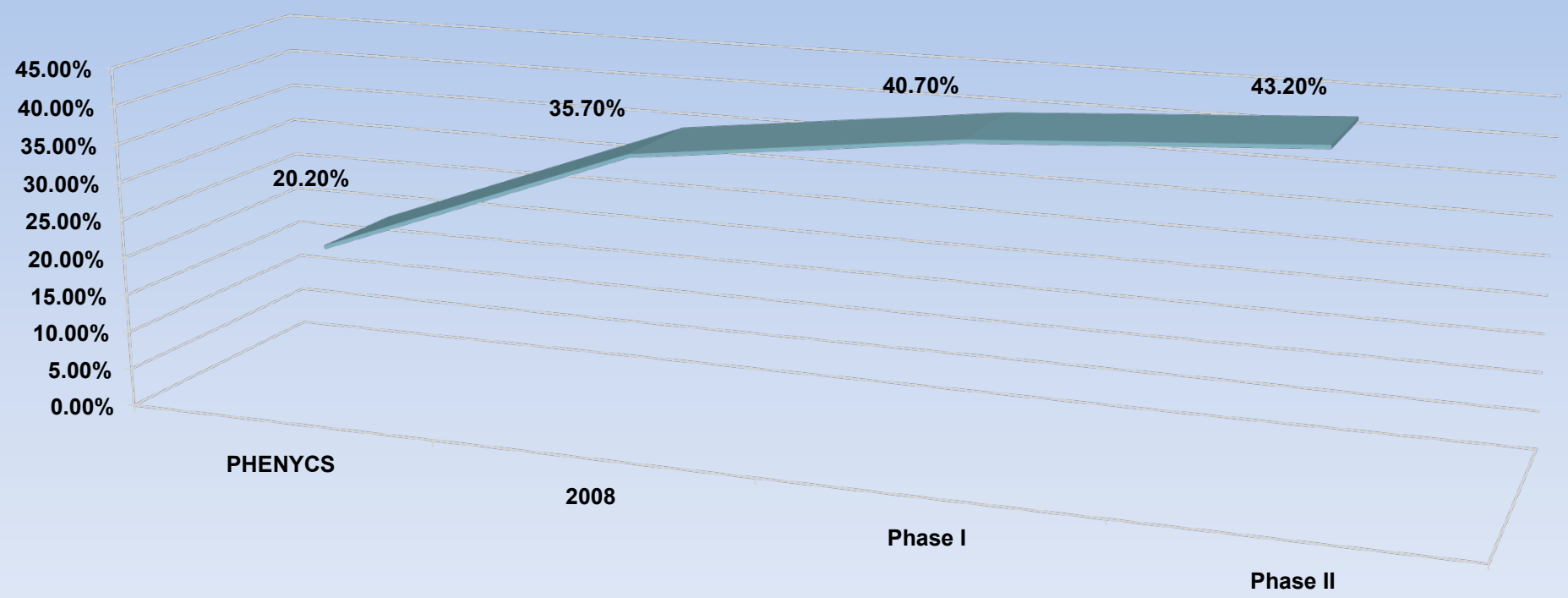
Feedback Loop



Feedback Loop



Background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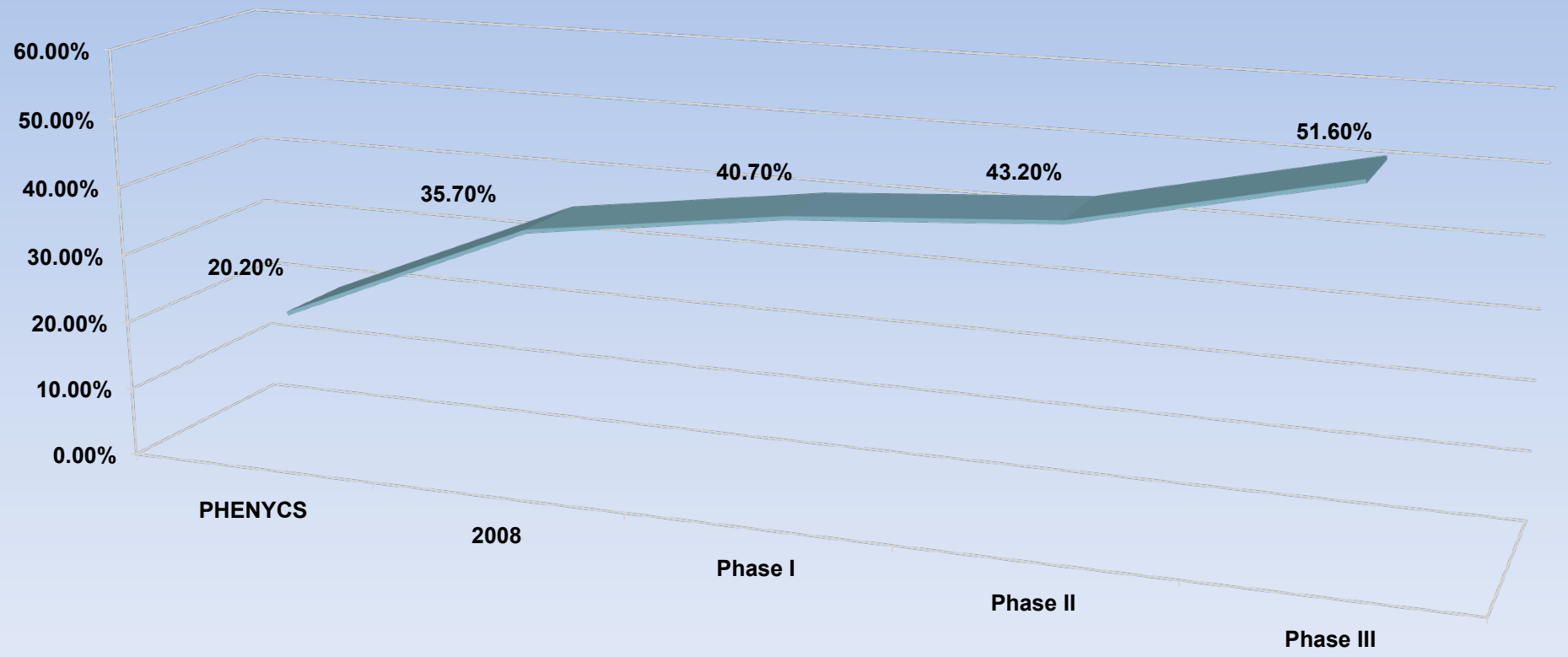
PHENYCS
2008
Phase I
Phase II

Feedback Loop

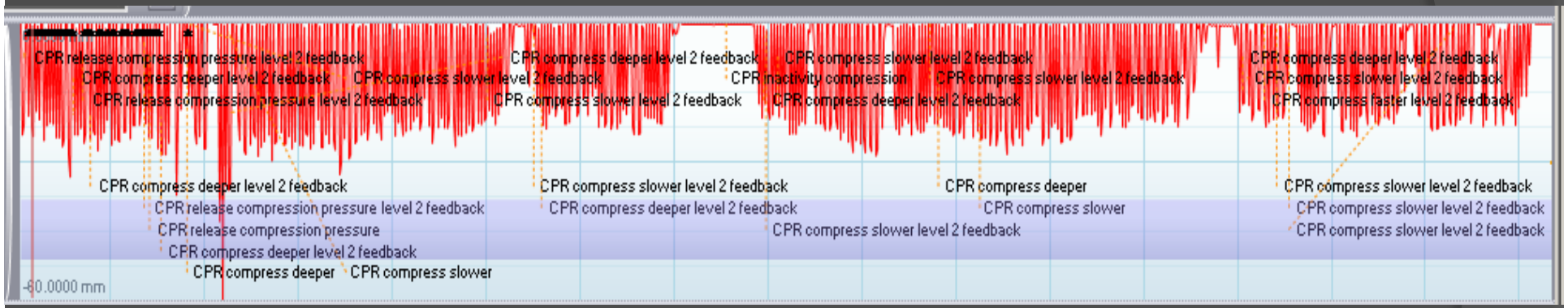


Feedback Loop

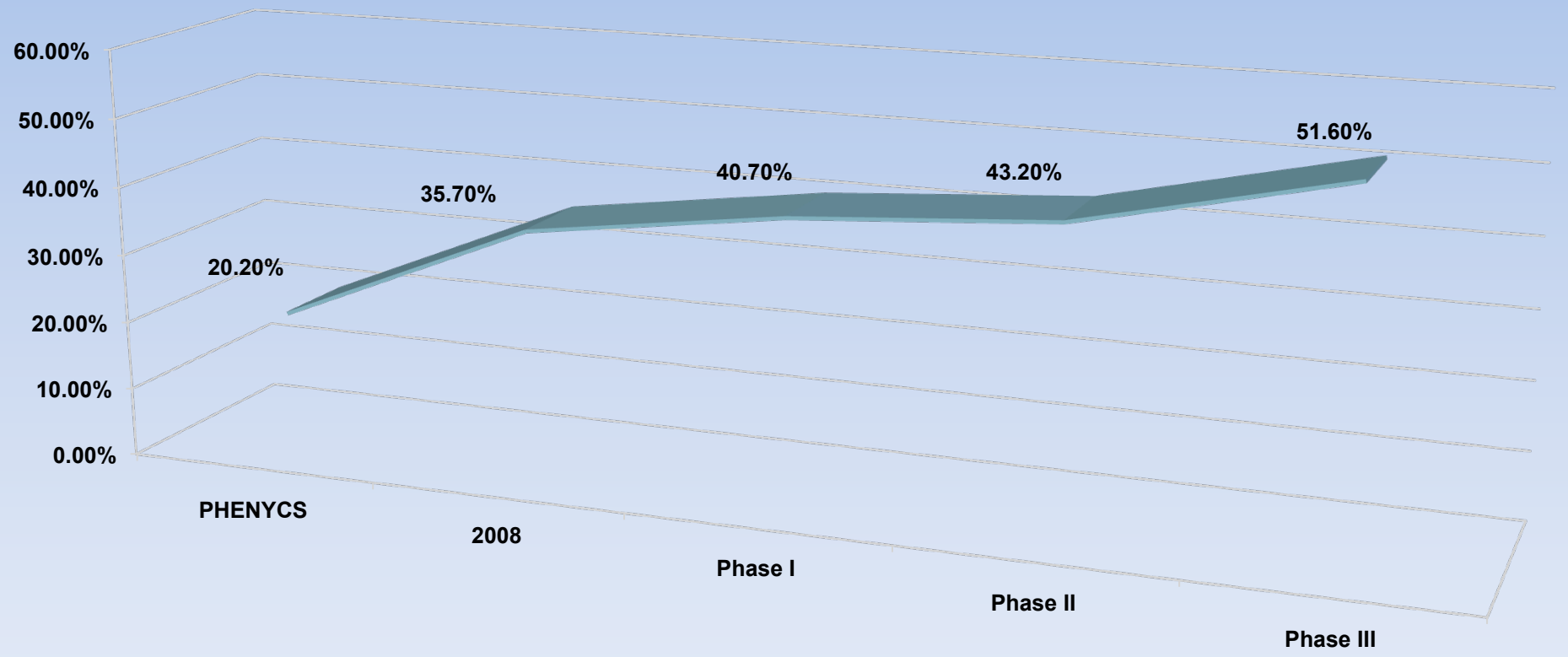
One Final Note – Voice Prompts

Feedback Loop

Voice Prompts

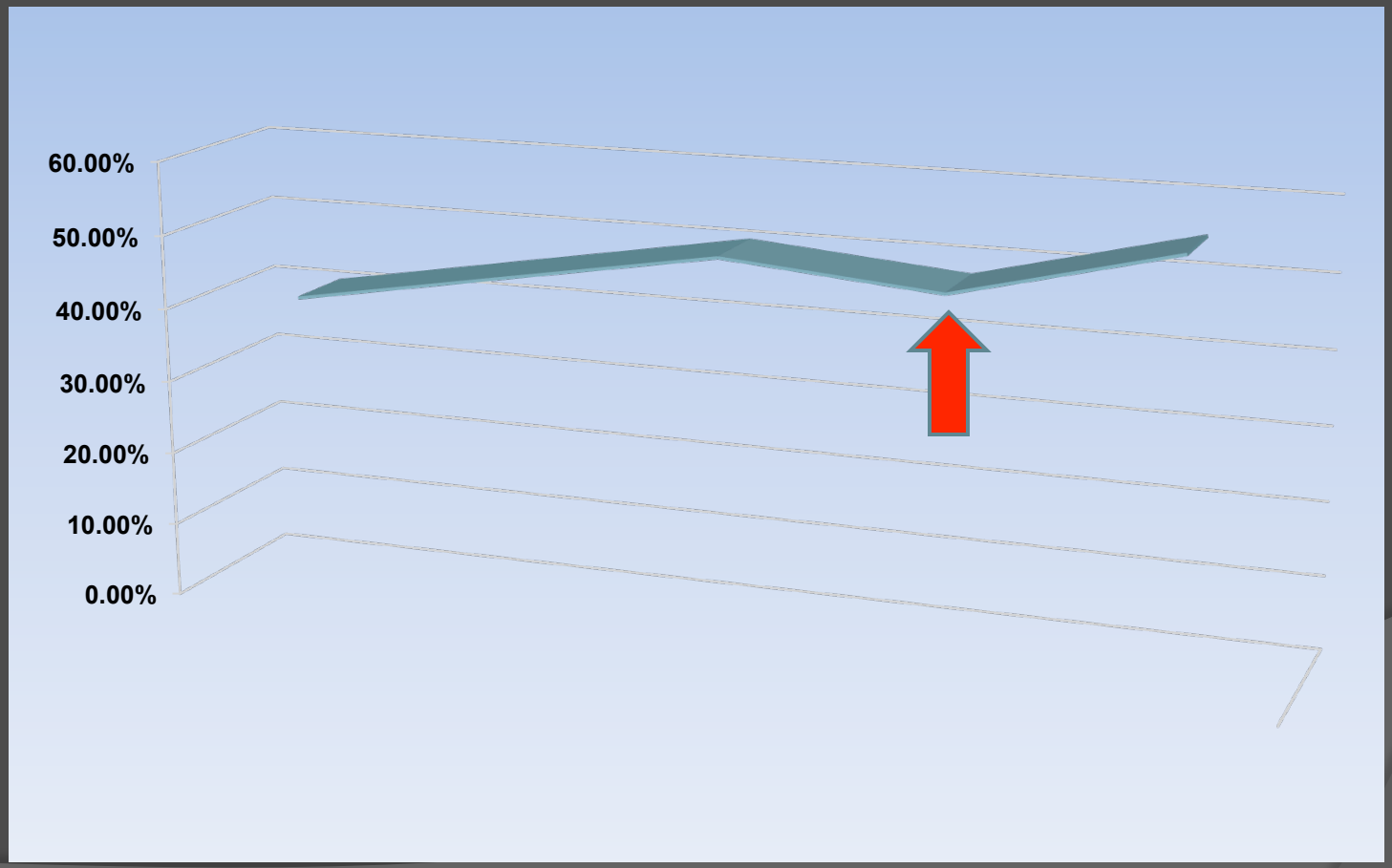


Feedback Loop



Feedback Loop

One Final Note – Voice Prompts



Feedback Loop

Conclusions

- measuring CPR performance is critical for quality improvement
- call review / post-event summaries / resuscitation rounds are fantastic

  …but don't help the patient in question
- quality compressions require attention to more than compression fraction
- real-time CPR feedback improves immediate outcomes
- voice prompts may further improve performance (peer pressure)


Thank you