
Case 11 - St. Swithin's Hospital

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Outline

- *Problem Statement*
 - *Assumptions*
 - *Model Development*
 - *Base Solution*
 - *Sensitivity Analysis*
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Problem Statement

- Dr. Susan Smith needs to develop the most optimal strategy to diagnose deep vein thrombosis (DVT).
- Untreated DVT can lead to a 12.5% chance of death while treatment of DVT by heparin can also lead to death and long-term disability.
- There are 3 diagnosis techniques, the Doppler Test, Venography, and IPG
- Dr. Smith needs to evaluate if the IPG diagnosis is superior than the other two or the combination of the other two diagnosis to determine if the hospital should acquire IPG capability
- The stakeholders are: the hospital, the doctors, and the patients.
- The hospital avoids lawsuits, the doctors avoid negative reputation, and patients avoid death

Assumptions

- Regardless of the diagnosis method and result, patients arrive at one of the following 3 states: Dead, Alive, or Long-term Disability.
- It is not allowed to conduct the same type of diagnosis multiple times; also, it is not allowed to give treatment without any diagnosis
- If a patient has DVT while undergoing Herapin treatment, the possible CVA occurs before the development of PE.
- The probability that a patient is non-diagnostic under Venography is independent of the patient's probability of having DVT, which means out of all patients who are non-diagnostic, 40% actually has DVT.
- In our base solution, we would use 40% as the probability that patients who have DVT symptoms actually have DVT. In sensitivity analysis, we will test if our decision is different under different percentage
- In our base solution, we use the least mortality as our objective function. We will discuss the change in results if we use the least wrong diagnosis and the least mortality/long-term disability caused by wrong diagnosis as our objective functions

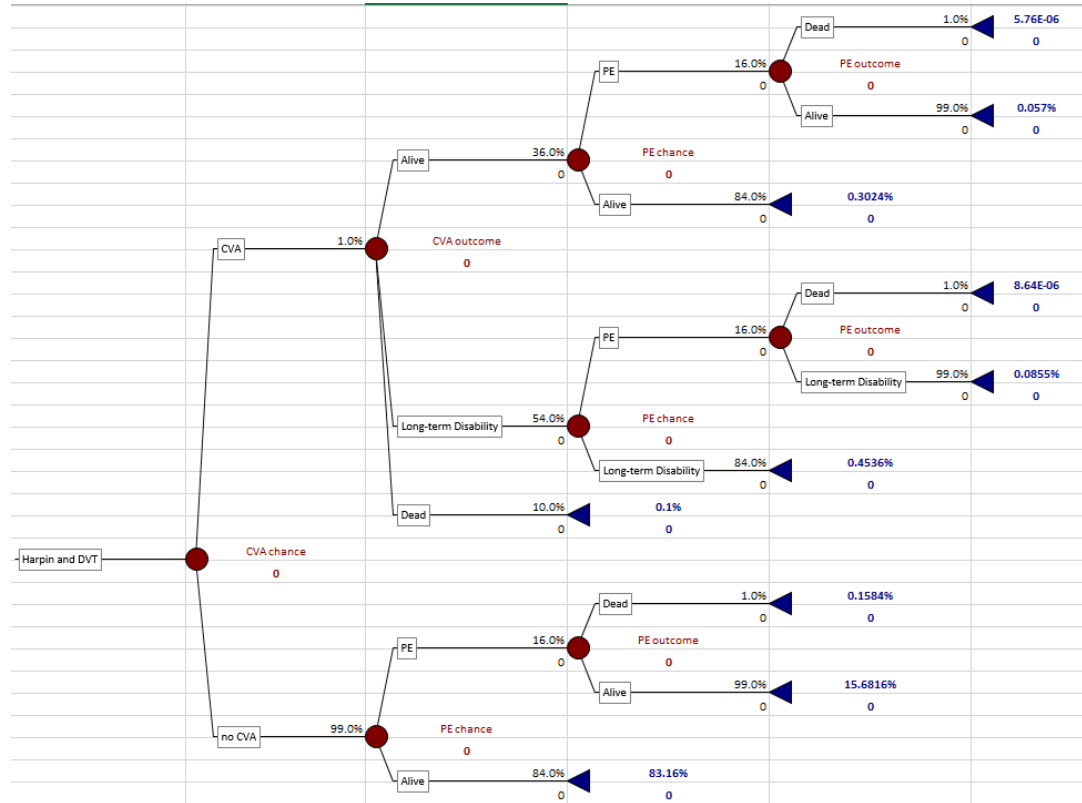
Model Development

After diagnosis, there are 4 results:

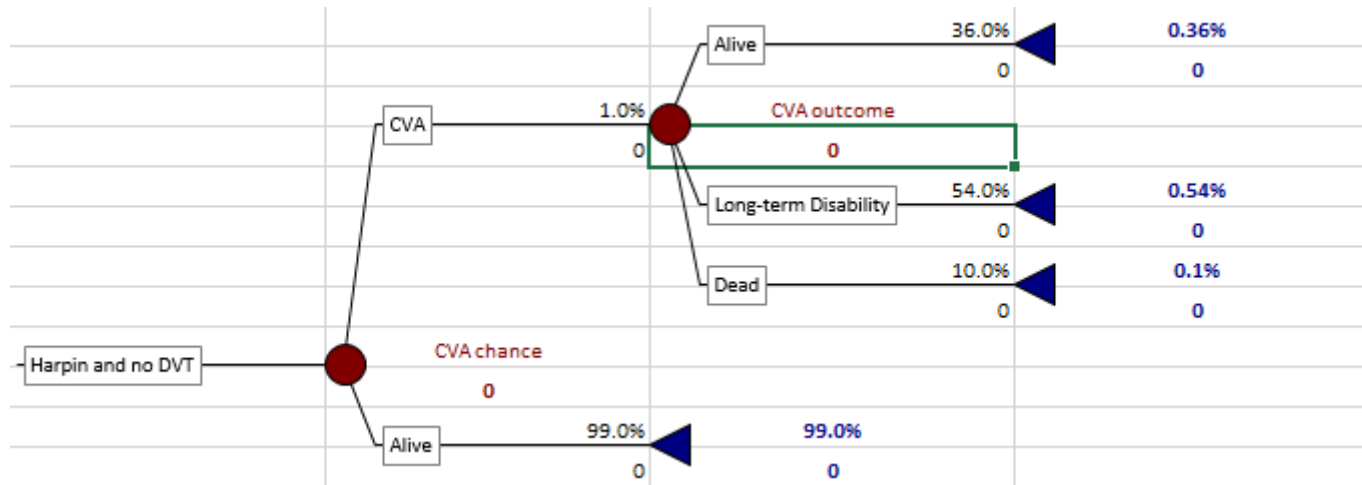
- Giving Herapin treatment while the patient has DVT
- Giving Herapin treatment while the patient DOES NOT have DVT
- Not giving Herapin treatment while the patient has DVT
- Not giving Herapin treatment while the patient DOES NOT have DVT

After calculating the overall percentage of alive, alive but long-term disabled, and dead patients, we can evaluate the effectiveness of each diagnosis by implementing these probabilities.

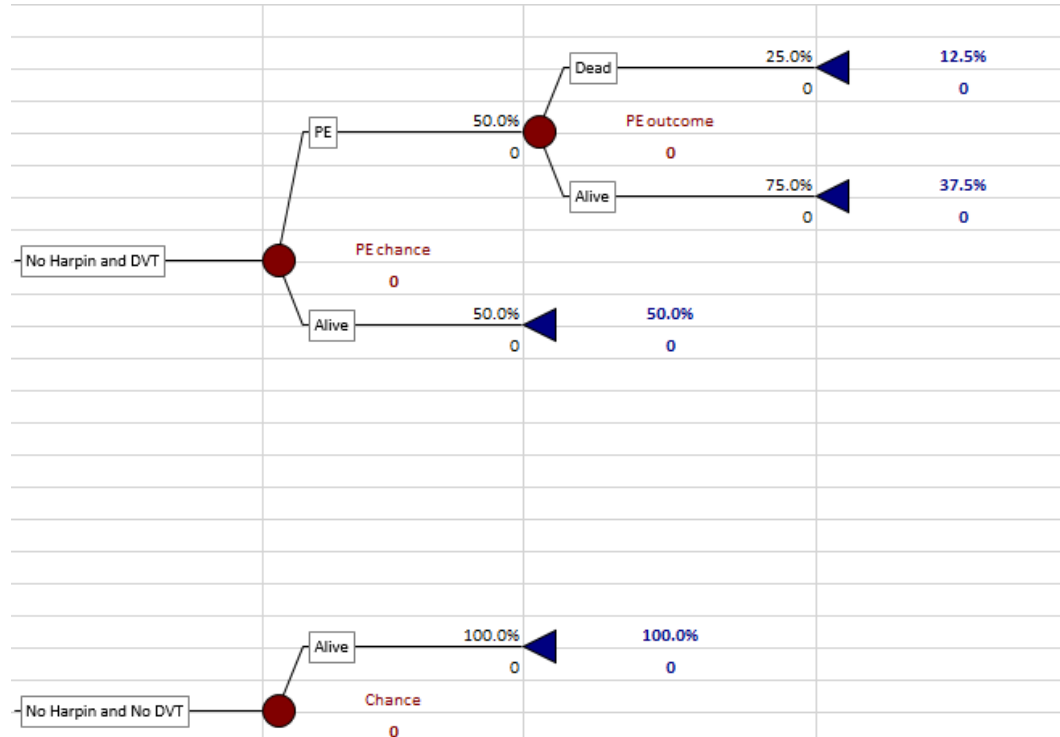
Model Development - Decision trees



Model Development - Decision trees



Model Development - Decision trees



Model Development - Cumulated Probabilities

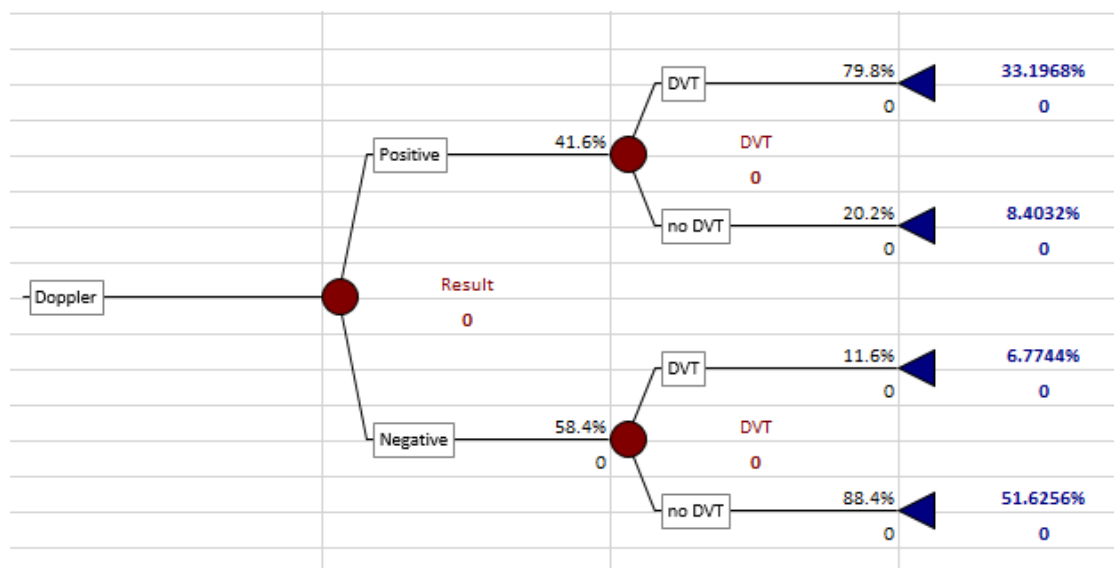
	Alive	Long-term Disability	Dead
Herapin and DVT	99.201%	0.539%	0.260%
Herapin and no DVT	99.360%	0.540%	0.100%
No Herapin and DVT	87.500%	0.000%	12.500%
No Herapin and no DVT	100.000%	0.000%	0.000%

Model Development - 4 diagnosis approaches

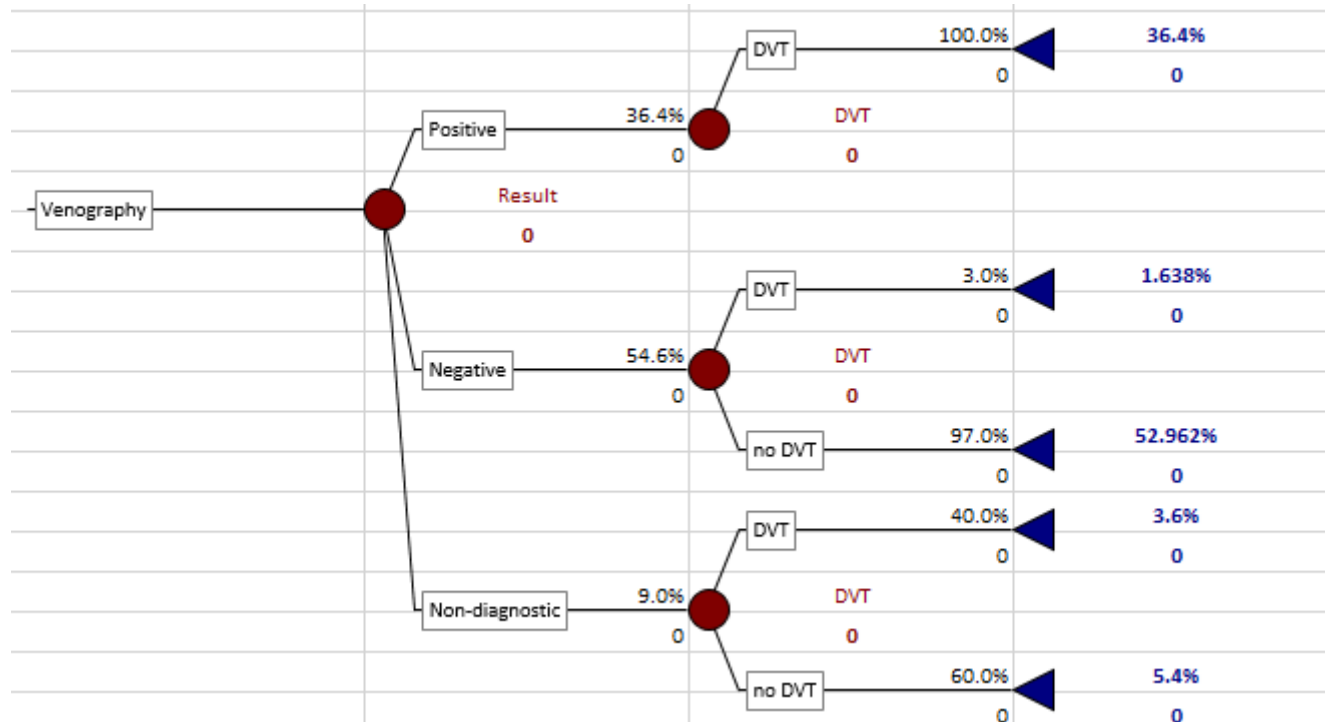
Since our objective is to find out if we should acquire IPG or not, we need to compare the Doppler test, Venography, Venography and then Doppler, with IPG.

The reason we choose Venography and then Doppler is that there are nondiagnostic patients in Venography diagnosis who will be treated with heparin anyways, which has a 60% chance of treating patients without DVT. Moreover, there are induced DVT patients from the Venography analysis, so an additional Doppler diagnosis is helpful to screen out as many undetected patients as possible. After all the greatest mortality rate comes from patients who are not given herapin treatment when they actually have DVT.

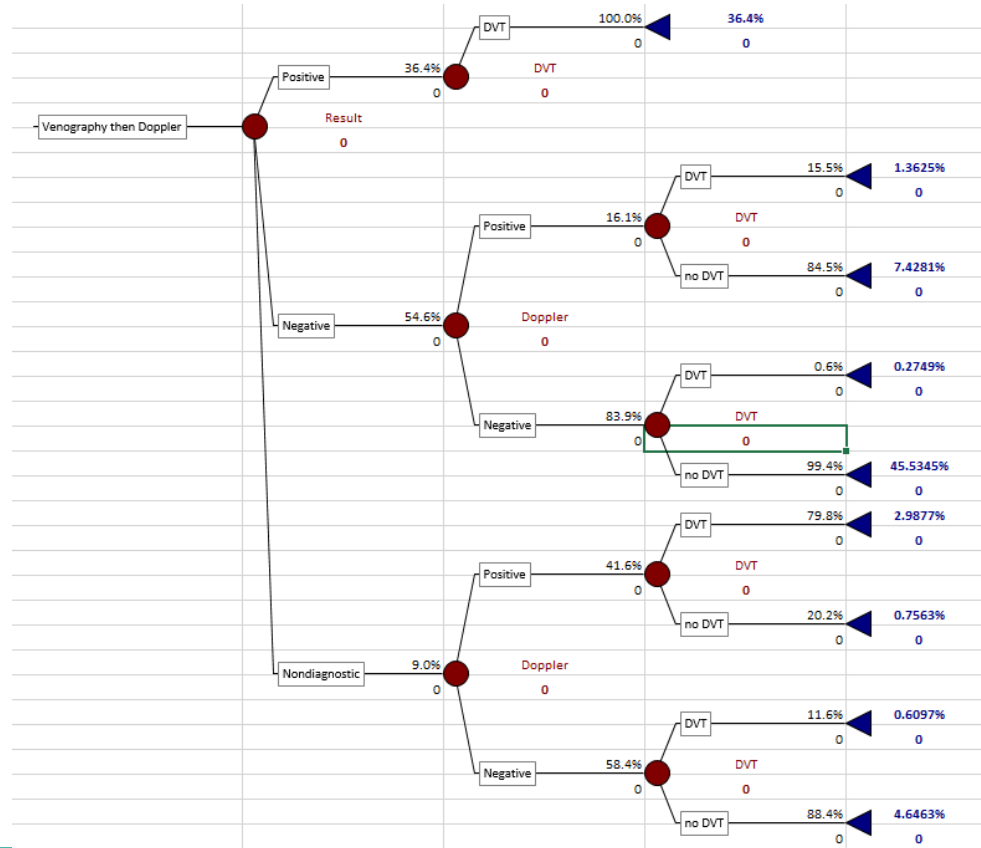
Model Development - Decision trees: Doppler



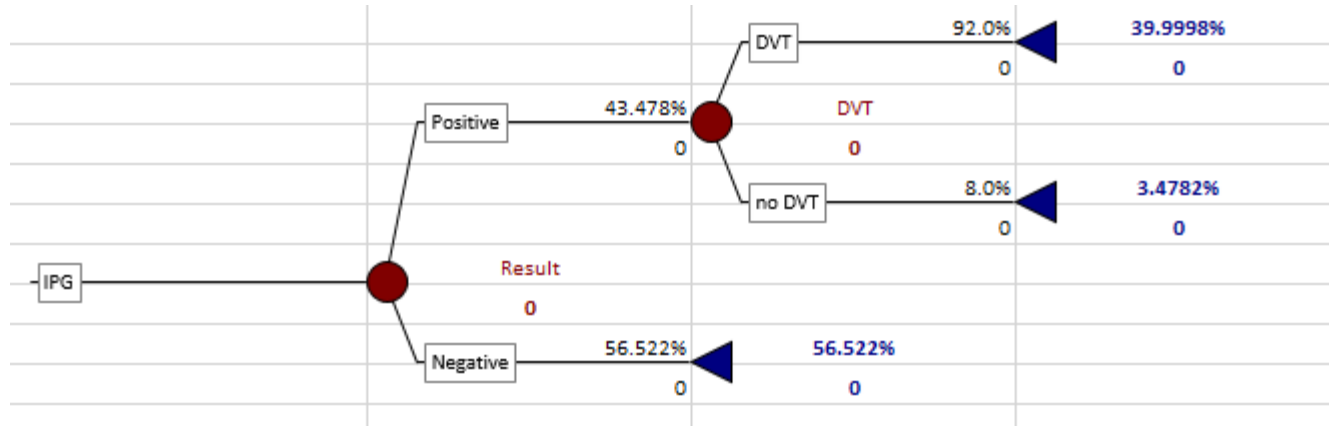
Model Development - Decision trees: Venography



Model Development - Decision trees: Venography followed by Doppler

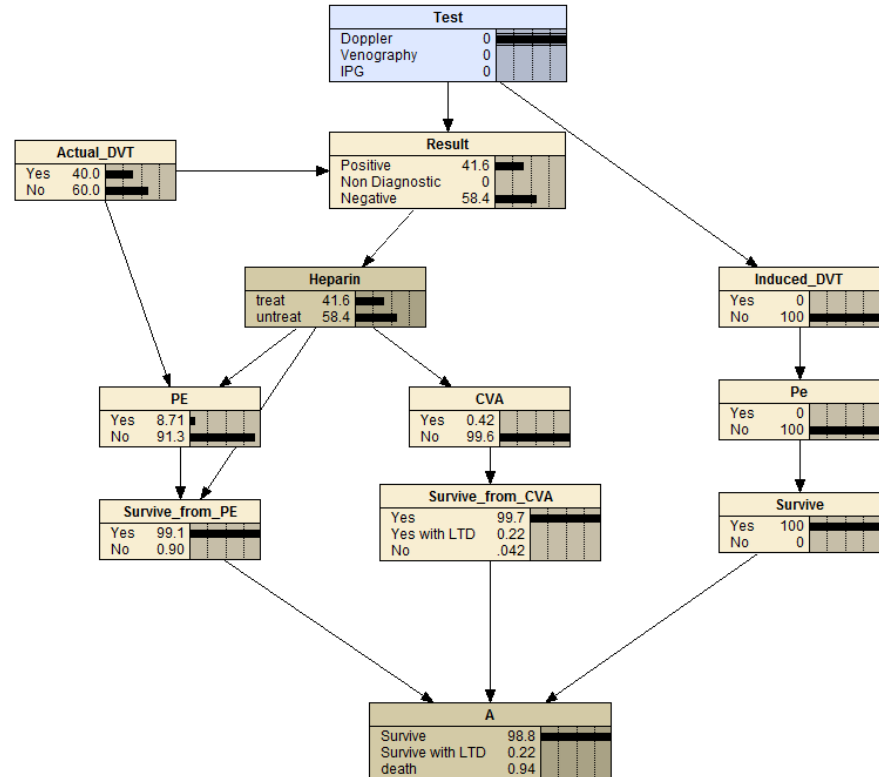


Model Development - Decision trees: IPG

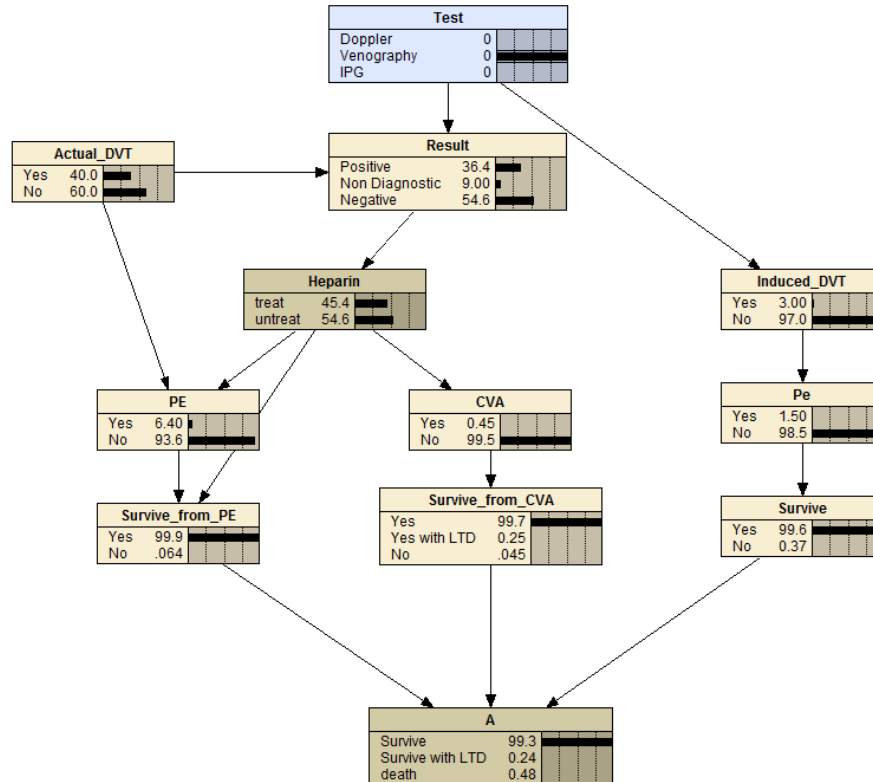


Base Solution - Doppler

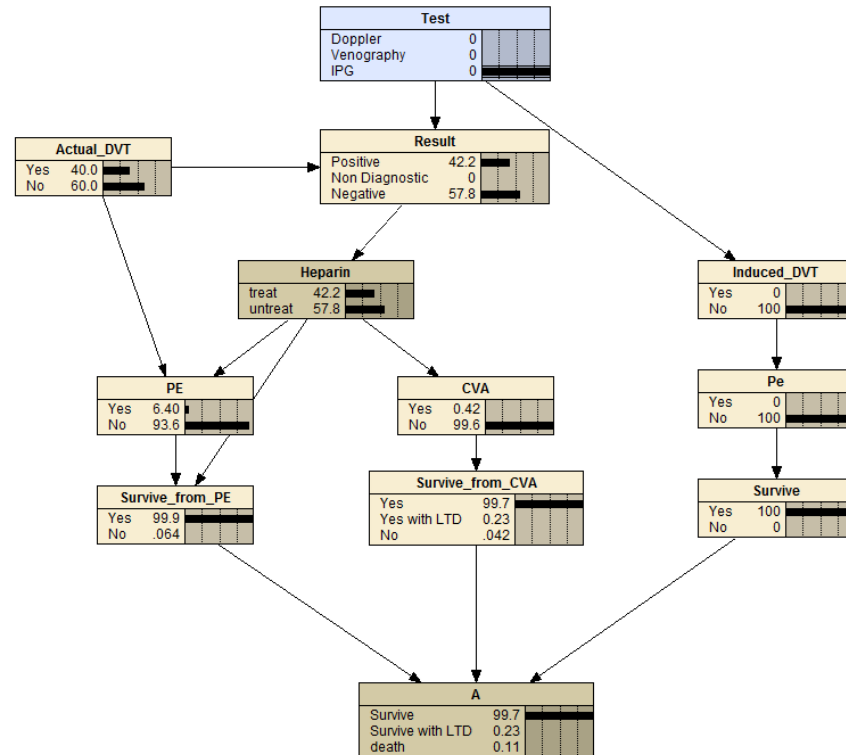
We used Netica for our calculation. The Precision Tree model is used to visually demonstrate the structure of our model. Netica, on the other hand, is much easier for calculation purposes.



Base Solution - Venography



Base Solution - IPG



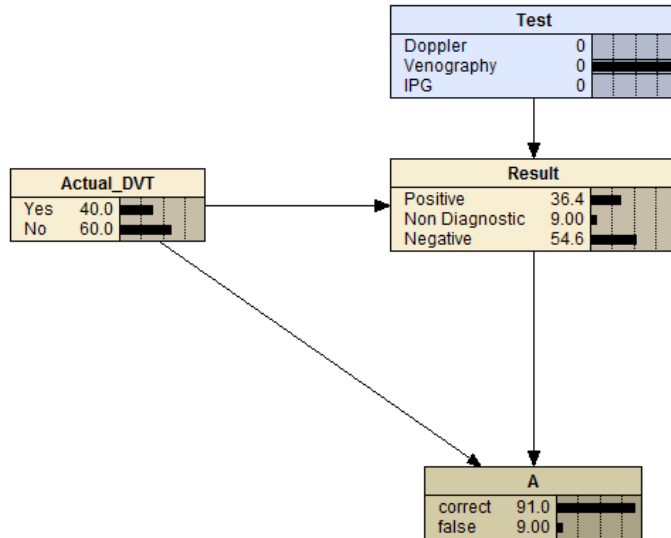
Base Solution

	Survival	Long-term Disability	Death
Doppler	98.8%	0.22%	0.94%
Venography	99.3%	0.24%	0.48%
Veno + Doppler*	99.5%	0.26%	0.24%
IPG	99.7%	0.23%	0.11%

*The mixed strategy, Venography and then Doppler is calculated from decision tree
Multiple test (combination of Veno and Doppler) is not suggested because it yields a lower survival rate than one of the single test, and it is still lower than single IPG.

Sensitivity Analysis - Doctor's Perspective

False diagnosis will damage the doctor's reputation, so we need to maximize the diagnosis accuracy. This is the structure of the respective model.

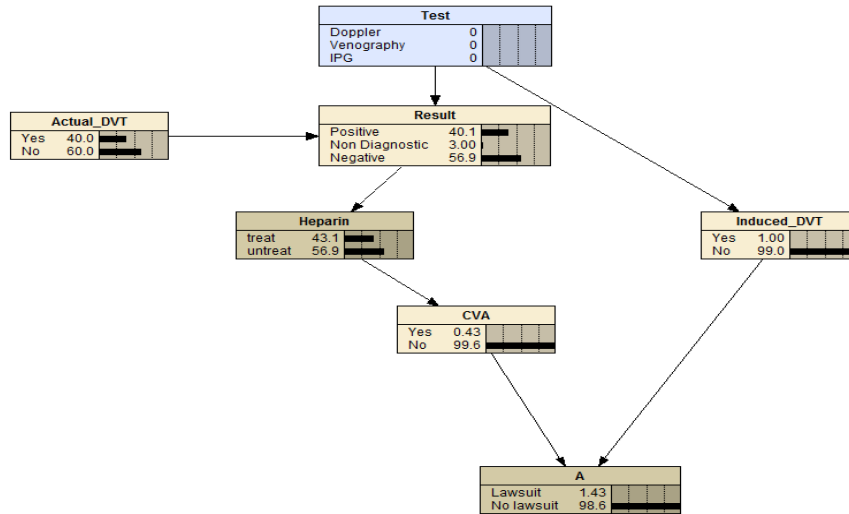


Rate of	Correct	False
Doppler	84.8%	15.2%
Venography	91%	9%
IPG	97.8%	2.2%

IPG has the highest accuracy in diagnosis while Doppler has the lowest. The differences in accuracy between IPG and Venography, Venography and Doppler are quite significant.

Sensitivity Analysis - Hospital's Perspective

Venography induced DVT and Heparin induced CVA may lead to lawsuit against the hospital. So from hospital's perspective, we need to minimize the probability of those two results.



Rate	Lawsuit	No Lawsuit
Doppler	0.416%	99.584%
Venography	3.440%	96.559%
IPG	0.422%	99.578%

Doppler has the lowest lawsuit rate while Venography has the highest. While IPG and Doppler has negligible difference in lawsuit rate, Venography has a significantly higher percentage.

Sensitivity Analysis - Different rate of having DVT

Since the TRUE rate of a patient with clinical symptoms actually have DVT is not known, we decide to change the rate to see how sensitive is our decision.

Rate	Doppler	Venography	IPG
20%	99.520%	99.566%	99.945%
30%	99.288%	99.541%	99.919%
50%	98.822%	99.491%	99.868%
60%	98.590%	99.466%	99.842%

Our decision is insensitive to the change in percentage of actual DVT patients since the survival rate decreases at similar paces as the patient rate increases.

Conclusion

- IPG has the lowest mortality and highest full-recovery rate, so acquisition of IPG capabilities is strongly recommended if the hospital aims for the best results for patients.
- IPG also offers the highest level of diagnosis accuracy which ensures the reputation from doctors.
- However, using the Doppler diagnosis has slightly lower probability for lawsuits, assuming that all patient families who suffered from induced DVT and died from CVA would sue the hospital. Nevertheless, the difference between Doppler diagnosis and IPG is negligible.